THE EEL RIVER ACTION PLAN

A COMPILATION OF INFORMATION AND RECOMMENDED ACTIONS

PREPARED FOR
THE EEL RIVER FORUM

PREPARED BY
EEL RIVER FORUM MEMBERS

REVISED DRAFT
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Eel River Forum

The mission of the Eel River Forum is to coordinate and integrate conservation and recovery efforts in the Eel River watershed to conserve its ecological resilience, restore its native fish populations, and protect other watershed beneficial uses. These actions are also intended to enhance the economic vitality and sustainability of human communities in the Eel River basin.

Charter Members
California Trout
CA Department of Fish and Wildlife
CA State Parks
Coastal Conservancy
Eel River Recovery Project
Eel River Watershed Improvement Group
Environmental Protection Information Center
Friends of the Eel River
Friends of the Van Duzen River
Humboldt County Resource Conservation District
Mendocino County Resource Conservation District
National Marine Fisheries Service
North Coast Regional Water Quality Control Board
Pacific Gas and Electric Company
Potter Valley Irrigation District
Round Valley Indian Tribe
Salmonid Restoration Federation
Sonoma County Water Agency
US Bureau of Land Management
US Fish and Wildlife Service
US Forest Service
Wiyot Tribe

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Executive Summary

The Eel River is the third largest river entirely in California. The Eel River ecosystem, its salmon and steelhead populations, and other native fish and wildlife populations have been in decline for the past century and a half. It has been transformed from one of the most productive river ecosystems along the Pacific Coast to a degraded river with heavily impaired salmonid populations.

The mission of the Eel River Forum is to "**coordinate and integrate conservation and recovery efforts in the Eel River watershed to conserve its ecological resilience, restore its native fish populations, and protect other watershed beneficial uses.**" The Forum was convened in July 2012 and adopted its charter in June 2013.

The purpose of this document is to provide a summary description of issues the ERF has agreed are primary factors impairing salmonid recovery and ecological health of the Eel River.

Any "action items" identified by the Eel River Forum will be carried out by the Eel River Forum member organizations, not by the Forum as a whole.

Water Resources

Water is extracted throughout the basin for domestic and agricultural supplies and for hydropower generation at the Potter Valley Project. Water sustains multiple beneficial uses including supply, preservation of fish and wildlife, and recreation. Conflicts between instream needs and out-of-stream demands for water in the watershed are increasingly serious.

Despite the abundant water resources, the vast majority of the Eel River's water is delivered during high winter baseflows and large-magnitude winter floods during a seven month period spanning roughly November to May. Only 1.5% of the annual yield comes during the five driest months between June and October, and human demands peak as surface flows diminish.

Natural low-flow conditions in the Eel River have been compounded by human-caused factors, the most significant being: (1) sedimentation from timber harvest, landslides, and poorly constructed and maintained road networks; (2) conversion of pristine old growth forests to crowded stands in a heavily roaded landscape; and (3) increasing streamflow diversions as a result of legal water rights and illegal diversions for marijuana production.

Substantial resources must be dedicated to enforcement to address the numerous, significant diversions that continue to impair critical salmonid streams across the region. The lack of clear state policy protecting streamflow and the resources and beneficial uses dependent on those flows, as well as the lack of resources necessary to address these problems, complicates the effort to recover salmonids.

Water Quality

Water quality in the Eel River encompasses a very broad and complex set of interrelated issues. Concerns include excessive sediment and turbidity, elevated water temperatures, increased nutrient impairment, and presence of blue-green algae. Sediment and water temperature have received the most attention to-date. In addition to the State Water Board monitoring programs, citizen-monitoring groups, private and public land managers, non-profits and tribes are engaged in monitoring on a site-specific or landscape scale.

Sediment Impairment and TMDL Implementation

The discharge of excessive sediment from hillslopes and unimproved road networks has caused severe impairment to many watercourses and watersheds in the Eel River. Naturally high sedimentation rates have been well-documented in the Eel River, and increased delivery and storage of sediment in stream and river channels has been accelerated by numerous causes: forest management and timber harvesting activities, road construction, agriculture, urban stormwater runoff, and marijuana production. Human activities have major impacts on forest and aquatic ecosystems.

Fortunately, sediment sources and hillslope erosion and delivery processes are comparatively easy to identify and quantify, and restoration treatments are straightforward and have become increasingly effective. State and federal resource agencies have focused extensively on this issue and have made more resources available.

Habitat Restoration and Enhancement

Restoration of degraded stream habitats is a critical component of any recovery strategy for the Eel River's natural resources. Many Eel River watersheds have been dramatically degraded from a century or more of poor land use practices. Although conditions in some have improved in response to regulatory program development, habitat quality remains in decline in many Eel River watersheds.

Stream habitat restoration has encompassed four primary areas of practice: 1) sediment reduction, 2) riparian restoration, 3) fish migration barrier remediation, and 4) instream wood placement to improve habitat complexity. Habitat restoration expenditures in the past 14 years have totaled approximately $280 million. The North Coast region and the Eel River restoration provides highly skilled jobs important to the regional economy.

In spite of refined techniques and millions spent on habitat restoration, few targeted salmonid populations show signs of recovery. Habitat restoration programs, by virtue of being competitive grant programs, spread limited resources across entire regions. In contrast, The State of Oregon has developed a restoration program that focuses on individual, high priority watersheds. In the next phase of habitat restoration in the Eel River, practitioners should bring their individual and collective expertise together to plan and prioritize restoration actions.

The Eel River Delta and Estuary

The Eel River delta and estuary is the third largest estuary in California. Estuaries are widely considered important nursery habitat, contributing significantly to the early life history of many fish species, including salmonids. The Eel River estuary has been designated critical habitat for salmon and steelhead under the Federal Endangered Species Act (ESA). Intact functioning estuaries provide watersheds with additional habitat diversity, which promotes life history diversity, which can lead to greater resiliency and productivity of salmonid populations at the watershed and regional scales. Ecosystem-focused restoration is preferred over a narrower focus on a specific species or life stage.

The Potter Valley Project

Since 1908, upper mainstem Eel River flows have been regulated, and water has been diverted to the Russian River Basin for hydroelectric power and agriculture via PG&E's Potter Valley Project. There are two major dams on the upper Eel River associated with the Project. Cape Horn Dam, which impounds Van Arsdale Reservoir, serves as the Project's diversion site. Cape Horn Dam is equipped with a fish ladder. Scott Dam, which impounds Lake Pillsbury, has no fish passage facilities. Recent studies estimate 100 to 150 miles of potential anadromous salmonid habitat have been blocked by Scott Dam.

The Project stores winter runoff in Lake Pillsbury, and then meters that water out through the year (particularly summer/fall) for power production and irrigation delivery in the Russian River watershed, and for fisheries protection in the Eel River. The current PG&E FERC license expires on April 14, 2022. To initiate the relicensing process, PG&E must file a Notice of Intent to File an Application for New License by April 14, 2017.

A 2004 license amendment was issued based in part on a 2002 NMFS Biological Opinion. The BioOp concluded that Project operations, as proposed, would have jeopardized the continued existence of listed anadromous salmonid species. This amendment led to a significantly modified streamflow regime below Cape Horn Dam to improve conditions for salmon and steelhead and promote timely downstream migration of juvenile salmon and steelhead, an annual monitoring program for salmonids and summer water temperatures, and Sacramento pikeminnow suppression and monitoring.

Monitoring

An inventory of current monitoring activities provides a framework for organizing and expanding future efforts, including biological, habitat and citizen-based monitoring. Monitoring provides essential information to inform decisions and actions.

Biological monitoring is focused on anadromous fishes of the Eel River (lamprey, sturgeon, salmonids), with California Department of Fish and Wildlife undertaking most ESA monitoring, and the Wiyot Tribe leading lamprey and sturgeon monitoring efforts. Some habitat monitoring overlaps with water quality monitoring, including flow, temperature, and sediment. Citizen-based monitoring primarily includes organized volunteer efforts and provides highly useful data.

NMFS recommends monitoring the impacts of loss of habitat, hydropower operation, harvest and overutilization, hatcheries, disease and predation, inadequate regulations and natural causes on salmonid persistence. All of these threats (except harvest) affect the broader biological community of the Eel River.

Community Engagement and Information-Sharing

The Eel River watershed encompasses a vast, rural area, with distinctly different human communities within its boundaries. These communities have varying capacities and needs for collecting and sharing data and conducting habitat restoration, water conservation, and other actions recommended throughout this Plan. The Eel River Forum recognizes that sharing information about watershed health, as well as coordinating and empowering citizen efforts, are critical to recovery of the aquatic species and health of the Eel River watershed.

1: INTRODUCTION: THE EEL RIVER AND THE EEL RIVER FORUM

The Eel River Forum has taken on a big challenge. Our Mission is to "**coordinate and integrate conservation and recovery efforts in the Eel River watershed to conserve its ecological resilience, restore its native fish populations, and protect other watershed beneficial uses.**" This mission will require a concerted, dedicated, and long-term effort. This effort isn't a new beginning. An enormous amount of regulatory and restoration planning, on-the-ground restoration work, and considerable financial investment have all been put toward the Eel River over the past several decades, much of that effort by current Forum members. Those past and on-going efforts have collectively described historical Eel River fishery and watershed conditions; surveyed habitat, sediment, fish migration, and riparian conditions in the watershed; and established restoration and monitoring programs to improve instream and watershed conditions. However, major challenges remain.

The Forum was convened in July 2012 at the invitation of California Trout after having discussed the concept with many current Forum members. From the initial meeting, however, the 22-member Forum representing public agencies, Indian tribes, conservation partners, and other stakeholders (Table 1) has clearly been the driving force. Following the initial meeting, the Forum convened nineteen subsequent meetings. A Charter was adopted in June 2013. Beginning in November 2012, a series of meetings with in-depth presentations and discussions spanned a broad range of issues central to salmonid recovery in the Eel River. Those issues included basin-wide monitoring activities, water quality and impaired summer instream flows, sediment and TMDL (Total Maximum Daily Load) implementation, an overview of the Eel River estuary, and a review of the Pacific Gas & Electric (PG&E) Potter Valley Project. All told, the Eel River Forum has spent nearly four years executing our Mission.

Table 1. Eel River Forum Charter Members.

California Trout
CA Department of Fish and Wildlife
CA State Parks
Coastal Conservancy
Eel River Recovery Project
Eel River Watershed Improvement Group
Environmental Protection Information Center
Friends of the Eel River
Friends of the Van Duzen River
Humboldt County Resource Conservation District
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North Coast Regional Water Quality Control Board
Pacific Gas and Electric Company
Potter Valley Irrigation District
Round Valley Indian Tribe
Salmonid Restoration Federation
Sonoma County Water Agency
US Bureau of Land Management
US Fish and Wildlife Service
US Forest Service
Wiyot Tribe

This first phase of the Eel River Forum has thus provided a broad review of some of the main issues impairing the watershed and its aquatic resources, brought forth from many different perspectives. The purpose of this document is to provide a summary description of issues the ERF has agreed are primary factors impairing salmonid recovery and ecological health of the Eel River. This document is not meant to provide a comprehensive, in-depth description of all factors impairing salmonids. In this document, each of these issues is summarized, relying on the past year's Forum presentations and discussions, and embellished with supporting information that may be available from literature, documents listed in our draft Charter, and/or drawing upon our own collective professional knowledge and experience. As a primary outcome of this exercise, we identify a set of actions or tasks that the Eel River Forum members support, and which would contribute to improving watershed/fisheries conditions, mitigating impairments, or solving the problem.

The initial focus is therefore: (1) identification of issues the Forum wishes to focus on; (2) prioritization of those issues to achieve a logical working order, and assembly of subcommittees or working groups as needed; and (3) development of strategies and actions to address issues prioritized by the Forum.

Actions developed by the Eel River Forum are meant to complement but not replicate existing or ongoing watershed and recovery plans.

A preliminary summary of the primary issues and related topics includes the following:

- Streamflows: effect of winter and summer diversion on instream habitat, water right policy, regulation and compliance, water conservation and flow restoration , effects of forest seral stage on low summer streamflows;
- Sediment Impairment: 303d listings, Clean Water Act TMDL development and implementation, forestry and road-related sediment sources, suspended sediment and turbidity;
- Delta and estuary habitat conditions: flooding and sedimentation of bottomlands, land conversion from/to wetlands, tide-gate and levee hydrologic effects on habitat, fish passage, agricultural land uses, practices, and value, delta and estuary habitat restoration;
- The Potter Valley Project;
- Monitoring: salmonid Endangered Species Act (ESA) status and trend of spawning adult abundance, population spatial structure, population diversity, and population life phase survival monitoring, pikeminnow monitoring, water quality monitoring, fish habitat restoration effectiveness and validation monitoring, tributary and mainstem flow monitoring, and funding for any of these efforts.
- Fish passage migration barriers, fish species and life phase migration barrier assessment and project prioritization;
- Gravel extraction;
- Research needs: instream flow assessment methods, summer flow losses, summer flow and rearing habitat quantification, pikeminnow suppression effectiveness;
- Data management: need for a centralized spatially based database for reports, documents, information, KrisWeb;
- Water quality: water temperature impairment, nutrients and contaminants, toxic algae;
- Stakeholder communications and collaboration throughout the basin;
- Funding sources and needs.

The “action items” identified by the Eel River Forum will not be carried out by the Forum as a group, but by the Eel River Forum member organizations. As stated in our Charter, the Eel River Forum is a voluntary organization and has no powers or authorities beyond those already possessed by its member organizations. The agencies, organizations, and interested parties are not obligated to adopt or carry out recommendations of the Forum, but will give due consideration to reasonable recommendations.

The Eel River Watershed

The Eel River is the third largest river entirely in California, covering 3,684 square miles, and contains approximately 3,526 stream miles (CDFG 2010). The mainstem Eel River is approximately 197 miles long and receives flow from 832 perennial tributaries. Numerous large and productive sub-basins and tributaries join the Eel River (Figure 1), including the North Fork Eel River (286 mi^2), the Middle Fork Eel River draining the Yolla Bolly Wilderness (753 mi^2), the South Fork Eel River (689 mi^2) considered as a Salmon Stronghold (Wild Salmon Center 2012), and the Van Duzen River (420 mi^2). The majority of the watershed is privately owned and managed for timber production, cattle and dairy ranching, but also includes several State Parks, the Yolla Bolly Wilderness Area, several Native American tribal lands, as well as portions of the Mendocino and Six Rivers National Forests. The river has both State (1972) and Federal (1981) Wild and Scenic River status. There are 97 miles (156 km) classified as Wild and 28 miles (45 km) classified as Scenic along the river's course.

Figure 1. Map of the Eel River Watershed, showing the seven major sub-basins.

The watershed is renowned for its high sediment loads, large rainfall-induced floods, and large annual water yield. The mean annual discharge for the Eel River at Scotia is approximately 5.8 million acre-feet, computed for this report by combining mean annual discharge estimates from the United States Geological Survey (USGS) Scotia and Van Duzen gaging stations (the NMFS 2002 BiOp reported a mean annual discharge of 6.5 million ac-ft [FERC 2000]). The December 24, 1964 flood of record at Scotia was 752,000 cfs. Fewer than 100,000 people live in the Eel River basin.

The California Department of Fish and Wildlife (formerly Fish and Game), in a 1965 report characterized the Eel River as ". . . one of California's most important anadromous fish streams; ranking second in silver (coho) salmon and steelhead trout production, and third in king (Chinook) salmon production" (DWR 1965). The basin once sustained large populations of Chinook and coho salmon, winter and summer steelhead, and coastal cutthroat trout. In addition, there were small populations of chum and pink salmon and also spring Chinook salmon (Yoshiyama and Moyle 2010). Pacific lamprey and green sturgeon are also recognized as important native species. Historical accounts of the fishery in the Eel River describe excellent recreational salmon and steelhead fishing, and large commercial harvests were taken from the estuary from 1853 to 1922 (CDFG 2010). Fish counts were conducted at Benbow Dam on the South Fork Eel River from 1938 to 1975, and documented adult Chinook salmon, coho salmon, and steelhead runs ranging between 2,000 and 20,000 fish annually. Recently, the UC Davis Center for Watershed Sciences prepared an historical review of Eel River anadromous salmonids (Yoshiyama and Moyle 2010), in which they estimated combined annual salmon and steelhead runs in the Eel River exceeded one million adult fish in good years (~800,000 Chinook salmon, ~100,000 coho salmon, ~150,000 steelhead).

The Eel River ecosystem, its salmon and steelhead populations, and other native fish and wildlife populations have been in decline for the past century and a half since the start of Euro-American settlement in the region. Much of the decline in salmonid abundance may be attributed to loss or degradation of physical and biological conditions in the ecosystem caused by human activities (CDFG 1997), including commercial and recreational fish harvests and cannery operations, several periods of large-scale timber harvest, land conversions for agricultural activities, water developments and diversions, rural and urban residential development, introduction of non-native predatory pikeminnow, and a multitude of additional minor factors. The Eel River has thus been transformed from one of the most productive river ecosystems along the Pacific Coast to a degraded river with heavily impaired salmonid populations. The commercial fishery has been eliminated, and the recreational fishery has been reduced to a catch and release fishery.

Apart from this brief summary of the watershed, this document is not intended to comprehensively describe historical or current watershed and fisheries conditions in the Eel River Basin. There have been numerous resource agency programs and stakeholder efforts over the past several decades, either focusing on specific watersheds or on specific issues, species, and/or management actions. Taken collectively, those efforts describe historical and contemporary conditions along with the major causes of impairments. A condensed list of those efforts includes the following:

- The National Marine Fisheries Service (NMFS) has listed Southern Oregon/Northern California Coast (SONCC) coho salmon (1997), California Coastal Chinook salmon (1999), and Northern California steelhead (2000) as threatened under the federal Endangered Species Act. The Final NMFS SONCC Coho Salmon Recovery Plan (NMFS 2014) describes Eel River coho salmon and identifies needed recovery actions. NMFS has prepared a draft Coastal Multispecies Recovery Plan for Chinook salmon and steelhead, as of October 2015, which includes analyses of those two species in the Eel River.
- The California Fish and Game Commission also listed coho salmon as threatened in 2005. The California Department of Fish and Game (CDFG) *Recovery Strategy for California Coho Salmon* (2004) describes Eel River coho salmon and identifies recovery tasks for populations within the Eel River basin. The California Department of Fish and Wildlife (CDFW) Coastal Watershed Planning and Assessment Program has developed watershed assessments for the Salt River, the South Fork Eel, Lower Eel, and Van Duzen rivers, and is preparing a similar assessment of Outlet Creek.
- The United States Environmental Protection Agency (USEPA) has listed all seven sub-basins of the Eel River as impaired on the federal Clean Water Act 303(d) list, primarily for excessive sediment and increased water temperatures. From 1999 to 2007, the USEPA and North Coast Regional Water Quality Control Board (NCRWQCB) conducted sediment source analyses and water temperature modeling in support of TMDL allocations. These allocations have been adopted for each sub-basin, but implementation plans have not been developed. The Regional Board adopted the “Implementation Policy Statement for Sediment-Impaired Receiving Waters

in the North Coast Region" in 2004, and adopted the "Implementation of the Water Quality Objective for Temperature in the North Coast Region" in 2011.

- PG&E owns and operates the Potter Valley Project, which stores and diverts water from the Upper Eel River into the East Branch Russian River. Streamflows released to the Eel River were increased beginning in 1979 for the protection of Chinook salmon and steelhead, as part of the Federal Energy Regulatory Commission (FERC) relicensing process for the project. In 2004, FERC issued an amended project license incorporating the streamflow releases from the Reasonable and Prudent Alternative of the NMFS Biological Opinion (NMFS 2002). In fulfillment of the FERC license and the NMFS Biological Opinion, PG&E conducts a series of annual studies to document the status of fish populations and habitat conditions in the Upper Eel River. Ultimately, the results of these studies will be used to determine the need for changes in project operations to further protect fishery resources.
- The US Forest Service's Six Rivers National Forest and Mendocino National Forest have prepared Land and Resource Management Plans (USFS 1995). The US Bureau of Land Management (USBLM) has prepared Resource Management Plans for Eel River lands in their jurisdiction (USBLM 1992, 1996; USDOI 1994). The USBLM has also prepared watershed planning documents for the South Fork Eel River, North Fork Eel River, and the Van Duzen River, as part of the Northwest Forest Plan implementation.
- Green Diamond Resource Company completed an Aquatic Habitat Conservation Plan (GDRC 2007) and Humboldt Redwood Company has a multi-species Habitat Conservation Plan which includes an Aquatic Conservation Plan as one of its core elements for their timberlands in the Eel River (HRC, formerly PALCO, 1999).
- The UC Davis Center for Watershed Sciences completed a *Historical Review of Eel River Anadromous Salmonids, with Emphasis on Chinook Salmon, Coho Salmon, and Steelhead* (Yoshiyama and Moyle 2010). The Center for Ecosystem Management and Restoration (CEMAR) synthesized available information to describe steelhead/rainbow trout resources of the Eel River watershed (Becker 2010); additionally, CEMAR prepared a *Eel River Steelhead Restoration Opportunities Memorandum: A Review of Promising Actions for Restoring Steelhead in the Sub-basins of the Eel River Watershed* (Becker and Smetak, 2010).
- The Wiyot Tribe has completed a "Pacific Lamprey of the Eel River Basin: a Summary of Current Information and Identification of Research Needs" (Stillwater Sciences 2010) and is currently working on an Eel River Pacific Lamprey Barrier Remediation Plan and Limiting Factors Model, funded through the US Fish and Wildlife Service.
- The Eel River Recovery Project (ERRP) is a broad-based community initiative to address water conservation, nutrient pollution, and ecosystem recovery, and has galvanized community involvement through several important events. The ERRP has coordinated two consecutive years of adult fall Chinook salmon run timing and distribution in the river near Fortuna, has coordinated a citizen-based water temperature, nutrient, and water quality monitoring effort, and has held two successful Water Day events in 2012 and 2013 to inform watershed residents on water issues and the health of their watersheds.

Current Status of Salmonid Populations

The current status of salmonid populations is difficult to estimate for the entire Eel River basin. The NMFS 2011 status review of North Coastal Chinook salmon (Williams et al. 2011) concluded "The lack of population-level estimates of abundance … continues to hinder assessment of its status." CDFW currently conducts adult salmonid spawner surveys in Lawrence, Grizzly, Bull, Hollow Tree, Sproul, Outlet, and Tomki creeks. They also operate the Van Arsdale Fish Station (VAFS) at River Mile 158, 12 miles below Scott Dam at the end of anadromy. CDFG/CDFW has counted salmon and steelhead at VAFS since the 1940s (Figures 2 and 3). Recent abundance trends have been upward (NMFS 2011; CDFG 2012), but best estimates indicate salmonid abundance remains in the range of 1-5% of historical abundance (Yoshiyama and Moyle 2010). Yoshiyama and Moyle's 2010 *Historical Review of Eel River Anadromous Salmonids* concluded that "coho salmon, Chinook salmon, and steelhead are all on a trajectory towards extinction in the Eel River basin, with only winter steelhead being widely enough distributed and abundant enough to persist beyond the next 50 years." Not all Forum members or the public agree with this perspective.

Considerable effort has been made in recent years by resource agencies, private industries, conservation organizations, and other stakeholders to promote watershed restoration and protect the Eel River's fisheries resources and watershed health. There have been some encouraging signs of recovery, especially with several strong year-classes of Chinook salmon returning to the river. Chinook salmon adult returns at Van Arsdale Fish Station have exceeded historical returns in years 2010-2012; coho salmon counts at monitoring stations

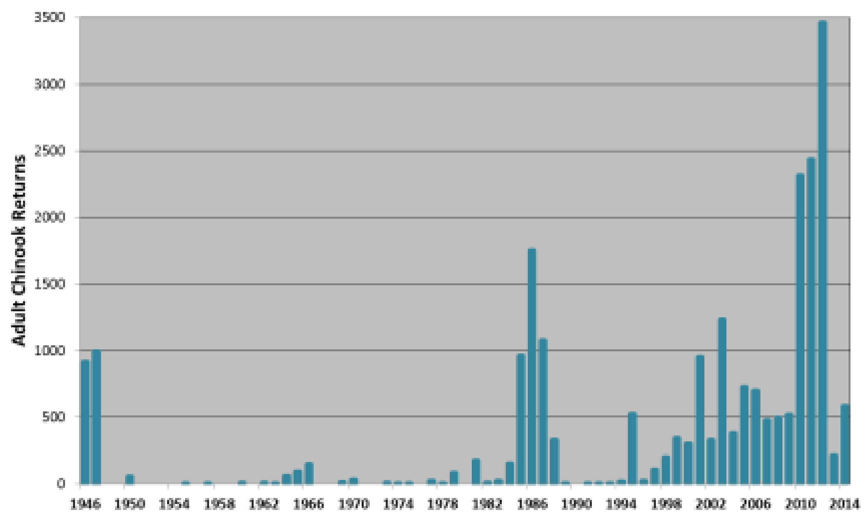

Figure 2. Annual adult Chinook salmon counts at the Van Arsdale Fish Station, from 1946 to present.

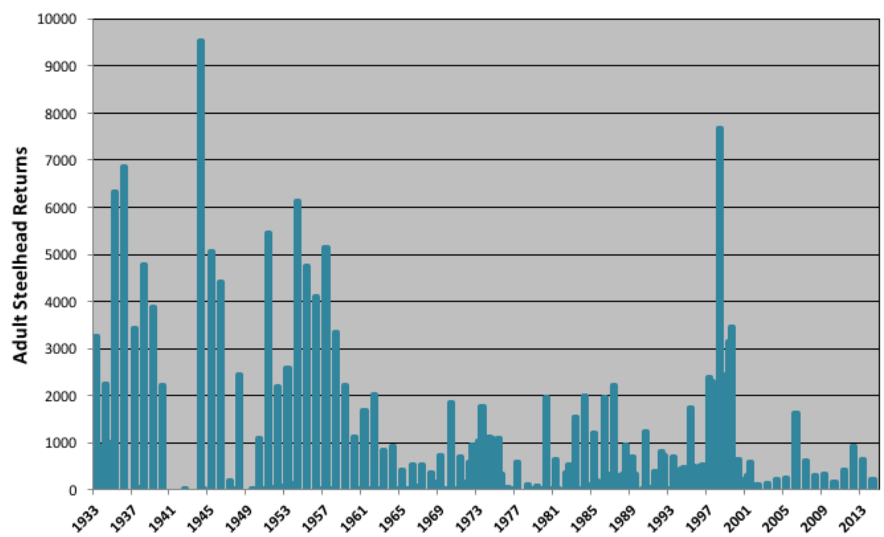

Figure 3. Annual adult steelhead counts at the Van Arsdale Fish Station, from 1946 to present.

in the South Fork Eel River have remained steady. Looking forward, the Eel River offers a unique opportunity for recovery; with concerted effort and continued restoration work, we have the opportunity to take significant steps toward salmonid recovery and ecosystem protection.

The Eel River needs real and concerted ***action***. Although the Eel River's salmonid populations may appear to be at less immediate risk compared to their southern neighbors (i.e., central and southern California), some populations are currently extirpated and continued decline appears to be imminent. Recent data show moderate increases in Chinook returns, offering the prospect that with concerted and coordinated restoration efforts, recovery is achievable.

2: WATER RESOURCES

Summary of the Issue

Water is perhaps the most important issue for salmonid recovery in the Eel River. Water is a valuable and critical resource, and is extracted throughout the basin for domestic and agricultural water supplies as well as for hydropower generation at the Potter Valley Project. Water also sustains multiple beneficial uses (defined by the NCRWQCB Basin Plan, NCRWQCB 2011b) including water supply, preservation of fish and wildlife resources, and recreation. The public trust doctrine recognizes the state's authority and responsibility to protect the trust uses of water, including fishing, navigation, commerce, and environmental quality. The conflicts between instream needs and out-of-stream demands for water in the Eel River watershed may not yet be intractable, but they are increasingly serious, and will require sustained effort over years and decades to support salmonid recovery.

Eel River Hydrology

One promising factor is just how much water the Eel River carries. A cursory analysis and summary of available USGS and PG&E streamflow data was developed for this document (and appears below), primarily to provide context for discussions of historical and contemporary flow conditions in the Eel River. Much more analysis of available data, as well as continued collection of existing and new streamflow data, is needed.

The basin-averaged annual rainfall in the Eel River is approximately 60 inches, although few sub-basins match these average conditions. Extremes are more typical in the Eel River. The headwaters of the Bull Creek watershed average 115 inches of rainfall annually, while the Eel River delta averages 35 inches (from State of the Eel River 1999).

The mean annual discharge for the Eel River (the average volume of water flowing out of the Eel River watershed in a year) is approximately 5.8 million acre-feet (maf). Mean annual discharge was computed for this report by combining yield data from the USGS 'Eel River near Scotia' (USGS 11-477000) and the 'Van Duzen River near Bridgeville' (USGS 11-478500) gauges. This estimate differs from the National Marine Fisheries Service (NMFS) 2002 Biological Opinion (BiOp), which reported a mean annual discharge of 6.5 million ac-ft (FERC 2000). Yoshiyama and Moyle (2010) report the same figure: "average annual runoff from precipitation in the entire Eel River watershed during the period 1951-1993 was 6.5 million acre feet," (citing SEC 1998 with data from EarthInfo 1994). However, it is not clear from what data these higher yield estimates are derived. The highest recorded annual discharge for the Eel River was 12.6 maf in 1983.

This enormous annual water yield places the Eel River among the highest in the state. The mean annual discharge for the upper Eel River watershed, estimated at Van Arsdale Dam, is approximately 455,000 ac-ft (based on unimpaired inflow to Lake Pillsbury for WY's 2004-12); the South Fork Eel River at Miranda (USGS 11-476500) has a mean annual yield of approximately 1.33 maf; the Middle Fork Eel River mean annual water yield is approximately 512,000 ac-ft. By comparison, the Trinity River and Russian River have mean annual yields of approximately 3.7 and 1.6 maf, respectively.

Extremes are typical of the Eel River. Despite the abundant water resources, the vast majority of the Eel River's water is delivered during high winter baseflows and large-magnitude winter floods during a seven month period spanning roughly November to May. Lisle (1978) states: "Runoff from the basin, averaging 890 mm annually [35 inches], is highly variable because of seasonality of rainfall, infrequent large storms, and poor retention of water in the basin. …Most importantly from a geomorphic standpoint, large flood flows are generated by moderately intense rain falling over the entire basin for a number of days and, in some cases, by snowmelt during warm winter storms. Little flood runoff is stored in the basin due to the steep slopes and constricted valley bottoms."

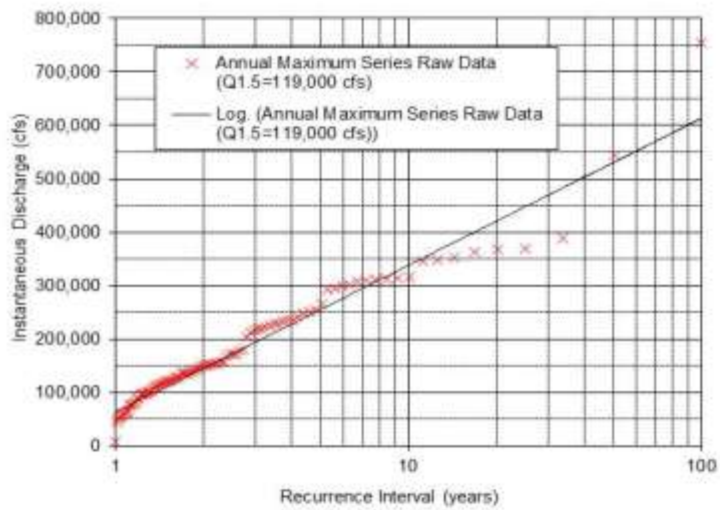

Figure 4. Flood frequency curve for Eel River at Scotia (USGS 11-477000).

Annual floods frequently exceed 100,000 cfs in the Eel River, and last several days; the 1964 flood exceeded 752,000 cfs at the Scotia gauge (Figure 4). Annual hydrographs for eastern sub-basins with higher elevation headwaters (North Fork, Middle Fork, Upper Mainstem above Scott Dam) also show a moderate spring snowmelt signature in many water years (Figure 5), but winter baseflow and rainfall-floods dominate the majority of the runoff.

Water availability concerns in the Eel River result from the fact that only 1.5% of the annual yield comes during the five driest months between June and October (Table 2). Human demands peak as surface flows diminish, placing a disproportionate burden on natural systems already operating at the extremes of their capacity. Streamflows in the mainstem Eel River below Scotia typically fall below 100 cfs by the end of the dry season in October, before the first rains arrive. Annual minimum flows for the South Fork Eel River near Miranda (USGS 11-476500; drainage area = 537 mi^2) ranged between 10 and 50 cfs across the 72 year period of record. Table 3 summarizes available USGS gauging data for the Eel River.

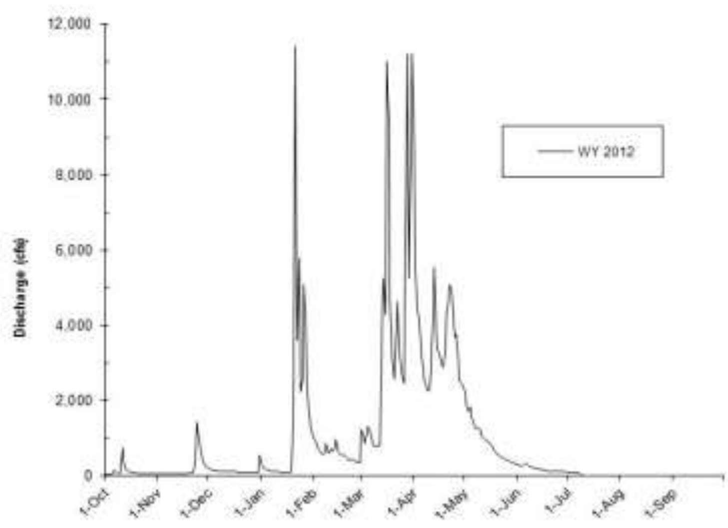

Figure 5. Annual hydrograph for the Middle Fork Eel River for water year 2012.

Low Summer Streamflows

Low-flow conditions were a common and natural hydrologic condition in the Eel River even when the watershed was pristine and streamflows were unimpaired. Analysis of precipitation and streamflow data for the North Coast and in the Eel basin particularly suggests that the length and severity of low flow periods in the Eel River have increased more than can be explained by variations in rainfall (Asarian 2014).

Table 2. Monthly and annual runoff volumes at Scotia (USGS 11-477000).

	Average Monthly (ac-ft)	Cumulative Monthly (ac-ft)	Cumulative Percent
Nov	274,374	274,374	5.3%
Dec	869,711	1,144,086	22.0%
Jan	1,180,638	2,324,723	44.7%
Feb	1,086,873	3,411,597	65.7%
Mar	877,165	4,288,762	82.5%
Apr	526,073	4,814,835	92.7%
May	228,999	5,043,834	97.1%
Jun	75,564	5,119,398	98.5%
Jul	20,730	5,140,128	98.9%
Aug	8,999	5,149,128	99.1%
Sep	7,947	5,157,074	99.3%
Oct	38,451	5,195,525	100.0%

It is generally accepted that natural low-flow conditions in the Eel River have been compounded by human-caused factors, the most significant being: (1) sedimentation from timber harvest, landslides, and poorly constructed and maintained road networks that cumulatively has filled pools, reduced pool volumes and reduced hyporheic (sub-surface) flow, and increased transient rates of water out of watersheds, (2) conversion of pristine old growth forests to crowded, thirsty stands in a heavily roaded landscape, (conversion of conifer-dominated forests to younger and more densely stocked deciduous-dominated forests that may increase evapotranspiration rates and thereby lower surface runoff) and (3) streamflow diversions which continue to increase as a result of (legal) appropriative and riparian water rights as well as unauthorized (illegal) diversions for marijuana production. Each of these factors contributes to further increases in water temperature, already a limiting factor for salmon survival and success during the region's warm summers and dry falls. Stressful salmonid rearing conditions that occurred in some areas in late summer and fall under natural, unimpaired watershed conditions have become more widespread, occur for a longer period of the season, and have more pronounced and severe consequences. Water temperatures are discussed in more detail in Chapter 3: Water Quality.

The severe state-wide drought that began in 2013 and continued through 2014 has further magnified the effects of already-amplified low flows, underscoring the extreme vulnerability of salmonid runs with low population numbers. Numerous salmonid-bearing streams across the region went dry earlier in the summer season than had ever been seen before, and springs and streams which had not failed in living memory also dried up during this drought. Unprecedented demand for water has led to extremes of human behavior (e.g, thefts of water from the Bridgeville School, a tank from a local volunteer fire department, water from ponds along South Fork Mountain, water bags on the South Fork at Redway) that underscore the urgent need to implement a reasonable and effective system of water regulation across the region.

Low summer discharges is a region-wide impediment to coho salmon and steelhead recovery, and has been recognized as such by several state and federal resource agency programs. The California *Coho Recovery Strategy* (CDFG 2004) states: "A substantial amount of coho salmon habitat has been lost or degraded as a result of water diversions …in some streams the cumulative effect of multiple small legal diversions may be severe." The NMFS SONCC Coho Recovery Plan (NMFS 2014) identified 'altered hydrologic function', including water diversion, as a key stressor (limiting factor) to juvenile coho salmon throughout the Eel River basin. NMFS (2014) also expressed concern regarding the downward trend in summer baseflow and reduced juvenile survival in the South Fork Eel River and Outlet Creek, perhaps the two strongest and most important coho salmon runs in the Eel River basin. The North Coast Regional Water Quality Control Board (NCRWQCB) has identified the task of developing an 'instream flow water quality objective' as a high priority. The instream flow objective would ensure natural hydrologic connectivity is maintained and protected in a manner that supports beneficial uses, including salmonid fish populations (NCRWQCB Water Temperature Policy Statement 2013). A peer review of the *State Water Board's Staff Report: Russian River Watershed* (Moyle and Kondolf, 2000) concluded: "[While] there is general agreement that there is little if any water available for diversion in the dry season, frequent winter flooding supports the view that water could be diverted in some winter months without harmfully affecting instream flows required by salmon, steelhead, and other public trust resources." River advocates asked the NCRWQCB to designate the Eel River and other North Coast rivers as impaired for low flows under §303(d) of the Clean Water Act, as other states have; the Board has so far declined to list California rivers, in favor of developing statewide criteria for low flows.

The Eel River Forum heard a presentation on general hydrologic processes in the watershed and potential effects from different land use practices over the past 150 years on streamflow and water quality (Brad Job, January 2013). Those practices include timber harvest in general, but more specifically the conversion of mature, conifer-dominated forests to younger and more densely stocked deciduous-dominated forests. Road construction may also contribute to lowering streamflows by intercepting shallow groundwater, thereby increasing the rate that precipitation, surface runoff, and shallow groundwater drain from the watershed. Surface diversions and groundwater wells for domestic water supply have also increased dramatically in recent years, and are contributing to surface flow depletions in many streams. Finally, climate change may be altering fog and precipitation patterns in the North Coast region.

Table 3. List of primary streamflow gages in the Eel River watershed operated by USGS.

Station Number	Station name	Drainage area (sq mi)	Datum of gage (ft above NGVD29)	Period of record (discharge)	Period of record ends (discharge)
Lower Eel					
11475000	EEL R A FORT SEWARD CA	2,107	217	10/1/1955	Present
11477000	EEL R A SCOTIA CA	3,113	36	10/1/1911	Present
11478500	VAN DUZEN R NR BRIDGEVILLE CA	222	358	10/1/1950	Present
11479560	EEL R A FERNBRIDGE CA	3,614	No data	10/23/1989	Present
South Fork Eel					
11475560	ELDER C NR BRANSCOMB CA	7	1391	10/1/1967	Present
11475610	CAHTO C NR LAYTONVILLE CA	5	1650	10/3/2007	Present
11475800	SF EEL R A LEGGETT CA	248	691	10/1/1965	Present
11476500	SF EEL R NR MIRANDA CA	537	218	10/1/2007	Present
11476600	BULL C NR WEOTT CA	28	269	10/1/1960	Present
11475700	TENMILE C NR LAYTONVILLE CA		No data	10/1/1957	9/30/1974
Middle Fork Eel					
11473900	MF EEL R NR DOS RIOS CA	745	902	10/1/1965	Present
Upper Eel					
11472000	EEL R A HEARST CA	466	No data	10/1/1910	9/30/1913
11471500	EEL R A VAN ARSDALE DAM NR POTTER VALLEY CA	349	No data	12/1/1909	9/30/2012
11470500	EEL R BL SCOTT DAM NR POTTER VALLEY CA	290	No data	10/1/1922	9/30/2012
11472150	EEL R NR DOS RIOS CA	528	1001	10/1/1966	12/31/1994
11472200	OUTLET C NR LONGVALE CA	161	1018	10/1/1956	11/6/1994

The CA Department of Fish and Wildlife has also documented effects of "quasi-legal large-scale" marijuana production on private lands, and presented this information to the Eel River Forum (Bauer, January 2013, see also: Bauer et al. 2015). CDFW and other agencies (e.g., see Carah et al. 2015) have documented a variety of impacts, including illegal timber harvest and land clearing, construction of on- and off-channel ponds for water storage, soil erosion and sedimentation of streams, water diversions, and use of fertilizers, toxic chemicals (pesticides and rodenticides) and diesel fuel powering generators. CDFW has analyzed marijuana-related water demands in four North Coast watersheds, including three tributaries to the Eel River, concluding that the cumulative effect of multiple individual grow operations may be consuming more than 20% of the summer streamflow in these tributaries. CDFW (Bauer et al. 2015) used aerial imagery to estimate water demand associated with marijuana production in Redwood Creek (a large stream that flows to the Pacific near Orick); Outlet Creek (a tributary to the mainstem Eel River that includes the town of Willits and its environs); and two tributaries to the South Fork Eel River, Redwood Creek (with its confluence at Redway), and Salmon Creek (with its confluence at Miranda). In the watersheds with more cannabis cultivation, "the water demand for marijuana cultivation exceeds streamflow during the low-flow period" (Bauer et al. 2015) CDFW (2013) recently documented dead coho salmon and steelhead in China Creek (a tributary to Redwood Creek in the South Fork Eel River), a watershed highly impacted by marijuana-related water diversions. Mortalities likely resulted from severely impaired food availability, due to dry riffles (CDFW 2013).

The California Advisory Committee on Salmon and Steelhead Trout weighed into the issue, issuing a letter to CDFW Director urging the Department to "focus even greater attention on the growing impacts to salmon and steelhead of marijuana cultivation, and to better coordinate its activities in this regard." The Committee noted that marijuana cultivation can have negative consequences on fisheries and water resources if it is conducted without adequate safeguards.

Water Policy and Regulations Protecting Streamflows

State laws, including the California Water Code, California Fish and Game Code, and the public trust doctrine require protection of salmonid and other aquatic resources. While water quality impacts are regulated by the North Coast Regional Water Quality Control Board, surface water diversions are regulated by the State Water Resources Control Board (SWRCB). The Eel River Forum was presented with an overview of water rights by SWRCB staff (McCarthy 2012). The presentation described (1) riparian and appropriative rights, (2) the SWRCB programs for registration of appropriative water rights, including Small Domestic Use, Livestock Use, and Small Irrigation Use, and (3) Statements of Use for surface diversions. Information is available online at http://www.swrcb.ca.gov/waterrights/board_info/.

To their credit, and with the encouragement of fisheries advocates, CDFW and SWRCB have responded to the 2013-14 drought by substantially streamlining their review requirements for Small Domestic Use registrations and associated §1600 permits. During the duration of the official Drought Emergency in 2014, the agencies were allowing applicants to self-certify their compliance with general criteria for the installation of water storage tanks. This allowed landowners to implement critically necessary water storage with a minimum of paperwork, securing both their valuable water rights and the public's interest in seeing water stored and streams protected. However, even the moderate response to the streamlined permitting process stands in contrast to the number of diversions which continued without permitting, adequate storage, or consideration of watershed impacts. While agencies may continue to offer the streamlined permitting process in recognition of the scale of the mismatch between actual and reported use, the fact remains that substantial additional resources must be dedicated to enforcement to address the numerous, significant diversions that continue to impair critical salmonid streams across the region.

Policies regulating surface water diversions in California's coastal watersheds have become an increasingly important topic in the past 15 years, and are of central importance to the Eel River given its large size, many appropriative and riparian water rights, and uncounted undocumented and unauthorized diversions. In 2004, Trout Unlimited and National Audubon Society submitted a *Petition for Timely and Effective Regulation of New Water Diversions in Central Coast Streams* (Roos-Collins, Gantenbein, and Bonham, 2004) to the State Water Board, describing the inadequacy of state guidelines and policy to effectively regulate water diversions. The 2004 petition noted that "The State Water Board does not have written guidelines (namely, policies which guide substantive review of water right permit applications) for the purpose of deciding how much water is divertible for water supply, and how much must remain to protect the cold-water fisheries in good condition". This fact has become even more relevant in recent years.

In 2002 the NMFS and CDFW prepared *Draft Guidelines for Maintaining Instream Flows to Protect Fisheries Resources in Mid-California Coastal Streams* (Draft Guidelines). The Draft Guidelines were prepared in response to the listings of coho salmon and steelhead and to address concerns that existing State guidelines and procedures, compliance, and enforcement intended to regulate water rights, water usage, and instream flows were not adequate to protect and recover anadromous salmonids in coastal watersheds. The Joint Guidelines proposed, for the first time in California's coastal watersheds, measures intended to provide the minimum conditions necessary for the protection of anadromous salmonids. The Joint Guidelines include: (a) an allowable season of diversion (December 15 to March 31), (b) a prohibition on on-stream reservoirs, (c) minimum bypass flows below points of diversion, (d) maximum diversion rates to avoid excessive cumulative diversions, and (e) fish passage and monitoring requirements. As of 2014 the State Water Board has not formally adopted these Guidelines nor any other regional water policies applying to the Eel River. In addition, several other critical issues remain unresolved, including appropriate methods to treat unauthorized diversions in cumulative analyses, compliance monitoring, and the scientific basis for determining minimum bypass flows (the flow which must remain in a stream below a water diversion) and maximum diversion rates.

In 2010, following a lengthy and arduous period of legislative initiative (AB2121), technical investigation, and policy development, the SWRCB adopted the *Policy to Maintain Instream Flows in Northern California Coastal Streams* (North Coast Policy). The North Coast Policy applies to watersheds from the Napa River to Mattole River, but excludes the Eel River. In addition, the guidelines only apply to winter diversions and do not acknowledge ongoing spring and summer water extraction.

In response to take of salmon and steelhead by pumping for frost protection of vineyards in the Russian River, the SWRCB promulgated *Russian River Frost Regulations* (Frost Regulations). Those regulations were challenged by wine grape growers in Mendocino Superior Court, which rejected the regulations as an unconstitutional overreach. In *Light v. SWRCB*, however, the California Court of Appeals upheld the Russian River Frost Protection regulations as a reasonable exercise of the State Water Board's authority and responsibility to regulate water diversions, particularly where necessary to protect public trust resources like fish and wildlife.

The *Light* ruling confirms the limits of fundamentally usufructory and relative rights to water, and the primacy of the public trust doctrine as the safeguard of instream flows. However, these SWRCB policies do not apply to the Eel River. And even if applied to the Eel River, they still would not provide adequate protection for threatened salmonid species and other aquatic resources and beneficial uses because they do not apply to the summer low-flow season.

Brief summary

In summary, the natural summer low-flow conditions annually occurring in the Eel River have significantly worsened in recent years and decades, resulting from past and ongoing human land use activities (e.g., timber harvest, rural development, marijuana production), as well as the severe, though not unprecedented, drought that has struck the region in 2013 and 14. These conditions severely challenge juvenile salmonids' capacity to survive increasingly harsh temperature and flow conditions. Already threatened, salmonid populations are being further, potentially critically, impaired throughout the region. Solutions to these key environmental problems are made more difficult by the lack of clear state policy protecting streamflow and the resources and beneficial uses dependent on those flows, as well as the lack of resources (primarily state agency staff scientists) necessary to address these problems.

Proposed Actions for Eel River Forum

1. Expand CA Department of Fish and Wildlife, Regional Water Board, and State Water Board Division of Water Rights staff to investigate, regulate, and monitor water rights and water diversions, and to establish instream flow objectives protective of fish resources in the Eel River watershed. The CDFW role in water rights has increased dramatically with the listing of anadromous salmonids, the implementation of SWRCB North Coast Policy and Joint Guidelines, and efforts to regulate summer diversions using Lake and Streambed Alteration Agreements. In recent years, CDFW has gained responsibility and oversight in the water rights regulatory arena, reviewing individual applications and touring project sites, making recommendations for protective measures, and preparing permit terms. In addition, at the watershed and cumulative effects scale, CDFW has gained responsibility for conducing water availability analyses and instream flow studies. The North Coast Regional Water Quality Control Board has identified the task of developing an 'instream flow water quality objective' as a high priority. The instream flow objective would ensure natural hydrologic connectivity is maintained and protected in a manner that supports beneficial uses, including salmonid fish populations (NCRWQCB Water Temperature Policy Statement 2013). Both these state agencies need additional staff scientists to accomplish planning, conservation, and enforcement activities related to water and streamflow management.

2. Obtain explicit recognition from the SWRCB supporting the *interim application* and *temporary extension* of the North Coast Policy to the Eel River. Interim policies and guidelines are needed immediately, to clarify and emphasize the importance of protecting public trust resources from over-allocation and over-consumption. Once implemented (on an interim basis), specific water right application projects that utilize these policies and guidelines should include adequate monitoring to verify their effectiveness and protectiveness of salmonids and other beneficial uses of water. As an interim policy/program, there should be adequate leeway to modify these guidelines if they are not effective.

3. Implement a basin-wide program to identify undocumented and unauthorized diversions and develop a mechanism to bring them into compliance with state water rights requirements; [(Roos-Collins, Gantenbein, and Bonham, 2004)].The State Water Board's 'Watershed Investigation Program' (WIP) may be an appropriate mechanism for this. SWB staff should align their WIP with priorities with those identified by CDFW and the Eel River Forum. Water users need to register their water use with the State Water Board, obtain a 1600 Agreement from CDFW, and identify bypass flows and diversion rates where applicable.

4. Establish an Independent Science Review Panel, similar to the Panel assembled to address the California Forest Practice Rules in 1998 (Ligon et al., 1999), to (1) address the 'inadequacies of existing regulatory mechanisms' in state policy regulating surface water diversions and the cumulative effects of multiple independent diversions within watersheds, and (2) oversee

refinement of scientific methods for establishing bypass flows below diversion sites and minimum flow thresholds protective of summer rearing salmonids. A March 1998 Memorandum of Agreement between NMFS and the state of California called for, among other requirements, a review and revision of California's Forest Practice Rules, and a review of their implementation and enforcement. That review was executed in 1999 (Ligon et al. 1999) and provided a substantive technical basis for revision of the Forest Practices Rules adopted in 2009. A similar process would provide an objective, credible assessment of water policy needs as well as guide development of instream flow science. The approach used in the Mattole River water conservation program and instream flow study (McBain and Trush, Inc. 2012) provides a potentially useful template (see point #7).

5. Prioritize water management and conservation programs in the Eel River at the sub-basin scale. Using the CalWater Hydrologic Basin scale watershed boundaries, determine the degree of overlap between domestic water demand and salmonid population abundance to effect the greatest benefits for time and resources invested (i.e., a high priority would be to invest where high value fisheries resources exist and where water demand is high). A strategic approach to conservation efforts is needed.

6. Conduct instream flow studies to establish instream flow objectives, bypass flows below diversion sites, and flow thresholds protective of rearing salmonids during the spring recession and summer low-flow periods. For water policy development and basin planning, instream flows protective of water quality beneficial uses and public trust resources must be prescribed throughout the region as a first priority for resource protection and conservation. These streamflow studies and the resulting state water policy eventually built upon them must withstand rigorous peer-review, and must allow some degree of regional extrapolation based on common metrics. For water rights holders and tank storage programs, robust instream flow studies are needed in order to prescribe minimum summer flows protective of juvenile salmonids, so that water diverters know when to turn off their diversion pumps and to consume stored water. Studies that link streamflows to specific life-history stages and rearing conditions is essential. A multi-phased project is needed that will first develop a study plan with local agency and stakeholder support, and then conduct the proposed studies. The goal of these studies is to provide working examples of the *physical methods and supporting biological data for establishing minimum instream flows protective of rearing salmonids during summer low-flow conditions.* A high-priority need for instream flow studies is to link physical habitat-based analyses with individual fish response (e.g., growth and survival), fish population response (e.g., recruitment and adult escapement), and stream ecosystem response (e.g., water quality and stream productivity). This linkage requires a robust fish sampling and monitoring program.

7. Rapidly expand water storage programs. In lieu of or in tandem with a "top-down" regulatory approach to water conservation, a grass-roots "bottom-up" approach to meet water demand during the summer/fall dry season is being pursued in the Mattole River and elsewhere, where summer water rights are foregone/traded for water storage facilities. A 2012 Salmonid Restoration Federation (SRF) presentation abstract by the Mattole's Sanctuary Forest Director Tasha McKee described the program as follows:

> "In the Mattole River headwaters there is no municipal water system and it is up to each landowner to develop and operate their own water diversion and water system. Over the last decade, several low flow years have underscored the need to change the timing of diversions and to develop a community approach for managing cumulative impacts. Sanctuary Forest developed the Mattole

> Headwaters Storage and Forbearance program in response to the severe low flows of 2002 and outcomes from community meetings. This voluntary, incentive based program helps landowners change their water use for the benefit of the river, fisheries and wildlife. Participating landowners forbear from exercising their riparian water rights during the low flow season, and receive a water storage system and water management guidelines to ensure an adequate water supply. Over the last 5 years [prior to 2012], 750,000 gallons of storage have been installed along with 12 forbearance agreements and measurable improvements in streamflow. …In the Mattole the development phase began with a feasibility study to determine if the program would be effective. The next steps included development of fisheries protection criteria, forbearance agreement, landowner outreach and education, and agency collaboration and permits. Ongoing implementation includes forbearance and storage installation along with effectiveness and compliance monitoring. Management of the program involves low flow season monitoring along with landowner notices and technical support needed to ensure forbearance. The program has been very successful, with increased water security for people and increased streamflow for salmonids. Education and outreach have fostered community appreciation and pride in the program with many households practicing conservation and installing some storage on their own."

This description of the Mattole watershed is illustrative of many locations in the Eel River watershed, and provides a practical solution to the problem of water over-allocation. Prioritization of this approach should be given to sub-watersheds with coho salmon populations with potential for restoring and/or maintaining cold summer streamflows.

8. Secure a reliable funding source and expand streamflow gaging throughout the Eel River watershed. Efforts to address streamflow and water temperature conditions in the Eel River will require discharge and temperature data. Water conservation efforts also require effectiveness monitoring in the form of flow data demonstrating improvements in surface flow. Streamflow gaging technology is now available to allow local watershed groups to install and operate gaging stations, but funding; education and outreach, and technical support are needed to enable this critical data to be collected. In addition, long-term gaging stations operated by the USGS need to be maintained in perpetuity.

9. Investigate benefits of long-term land management-based strategies (e.g., forest thinning, groundwater recharge) to increase summer baseflow.

10. Investigate feasibility and promote use of tax or other monetary incentives that encourage landowners to reduce summer diversions.

3: WATER QUALITY

Summary of the Issue

Water quality in the Eel River encompasses a very broad and complex set of interrelated issues in which the following water quality concerns are the major focus: excessive sediment and turbidity, elevated water temperatures, increased nutrient impairment, and presence of blue-green algae (cyanobacteria). Of these, sediment and water temperature have received the most attention to-date due to their inclusion on the USEPA's 303d list of impaired waterbodies and subsequent regulatory programs developed and administered by the USEPA and Regional Water Board (see the *Summary of Clean Water Act Enforcement* section immediately below). All seven sub-basins of the Eel River (Figure 6) are listed as impaired for sediment, six of the seven sub-basins are listed as impaired for water temperature (excludes the Van Duzen River) and several sub-basins are listed for other water quality constituents (Figure 6).

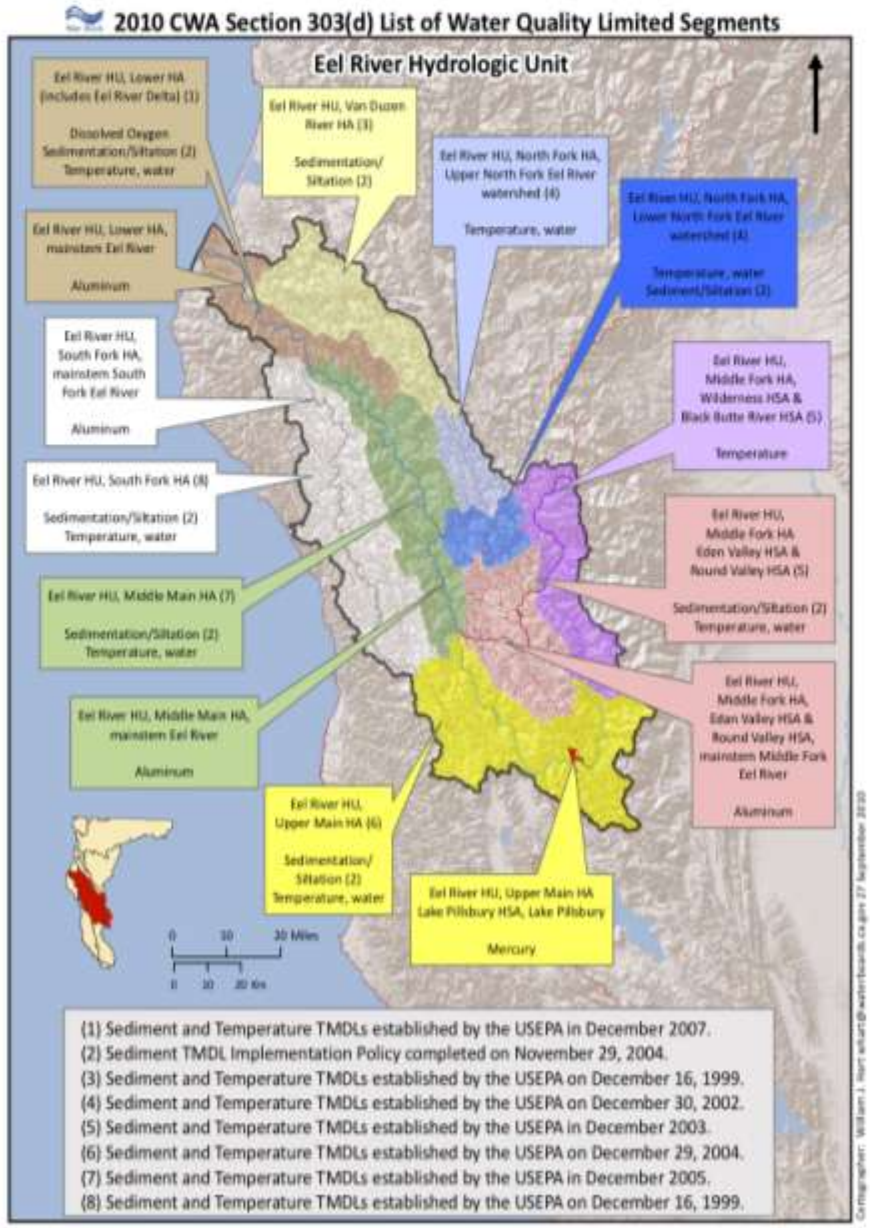

Figure 6. 2010 Clean Water Act (CWA) Map of the Eel River watershed and 303d listings, from the State Water Resources Control Board

An extensive amount of information is available on the subject of water quality impairment, especially due to TMDL program development and implementation in the Eel River. This section on water quality is focused on water temperature and blue-green algae. Sediment and flow conditions are addressed in other sections of this document (Chapter 2: Water Resources, Chapter 4: Sediment Impairment and

TMDL Implementation). Potential nutrient impairment and the additional 303(d) list of impairments are summarized below.

Presentations to the Eel River Forum by Regional Water Board staff described water quality regulatory programs and ongoing monitoring programs (McFadin 2012, McFadin and Geppert 2013). In addition to the State Water Board monitoring programs, citizen-monitoring groups, private and public land managers, non-profits and tribes are engaged in monitoring on a site-specific or landscape scale (see Chapter 8: Monitoring). Citizen monitoring is being used to supplement data from public agencies and can be used for trend monitoring and to help assess effectiveness of restoration.

Summary of Clean Water Act Enforcement

The Clean Water Act (CWA) has two approaches for protecting and restoring the nation's waters. The National Pollutant Discharge Elimination System (NPDES) permit limits that are used for point source end-of-pipe municipal and industrial wastewater discharge regulation. For non-point-source discharges, a water-quality based approach is designed to achieve the desired uses of a water body. The Basin Plan is the Water Board's water quality control planning document that designates beneficial uses and water quality objectives. The Basin Plan is used as a regulatory tool by the Regional Water Board's staff. Policy documents are written or updated as needed to define and refine the water quality objectives in Basin Plans.

In the water-quality based approach, once a water body is listed on the CWA 303(d) list of impaired water bodies, the process to establish Total Maximum Daily Load allocations is initiated. A TMDL is a calculation of the maximum amount of a pollutant that a body of water can receive and still safely meet water quality standards. Once the TMDL is adopted by the State Water Board, the Regional Water Board staff write NPDES permits and manage nonpoint sources through grants, partnerships, and voluntary programs to reach target TMDLs.

Water Temperature

Water temperature is one of the most simple water quality parameters that can be measured and has wide reaching impacts to riverine health. Water temperature is driven by solar incidence and stream conditions, such as stream channel geometry and flow. Direct exposure to solar radiation can impact water temperature. Shade provided by riparian cover helps maintain stream temperature and a lack of riparian cover can drive temperatures up. Elevated sediment loads can lead to changes in stream channel conditions that contribute to elevated water temperatures, such as wider, shallower channels, and reduced intergravel flow. Sediment may mobilize in a stream channel and settle into and fill deep pools. Deep pools typically stratify and provide refugia in the cooler water at the bottom of the pool. Sediment can fill these deeper sections and eliminate stratification, exposing salmonids and other aquatic biota to the higher temperatures of the stream. Similarly, reduction in stream flow may result in a reduction of pool depth, dry stream channels, and warmer water temperature.

Temperature directly governs almost every aspect of the survival of salmon and steelhead, and is such an important requirement that these species are known as "cold water fish." Salmon and steelhead are affected in many ways by stream temperatures, including metabolism, food requirements, growth rates, timing of adult migration upstream, timing of juvenile migration downstream, sensitivity to disease, and direct lethal effects (Spence et al. 1996.). There are a variety of chronic and sub-lethal effects that are likely to occur to salmon and steelhead species exposed to water temperatures that exceed their thermal tolerances. These effects include: reduced juvenile growth, increased incidence of disease, reduced viability of gametes in adults prior to spawning, increased susceptibility to predation and competition, and suppressed or reversed smoltification. Healthy fish populations may be able to endure some of these chronic impacts, but the cumulative effect of ongoing exposure to impaired water temperature conditions may eventually reduce the overall health and size of salmon and steelhead population. NMFS (2014) rated impaired water quality, primarily based on unsuitable summer water temperatures, as a high stress for all Eel River coho salmon populations (NMFS 2014).

According to the recently released Regional Water Board Water Temperature Policy Staff Report (Regional Water Board 2013):

> "Temperature impairments in the watersheds of the North Coast Region are predominantly associated with nonpoint sources of pollution, such as timber operations, agriculture, streambed alteration, land conversion and other construction activities. Temperature impairments are also associated with activities which do not generally involve waste discharge, such as vegetation alteration, water withdrawal, and hydromodification."

Between 1999 and 2007, the USEPA developed water temperature TMDL's for six temperature impaired sub-basins in the Eel River. However, the Regional Water Board had not begun developing temperature TMDL implementation plans for these sub-basins as of 2009. Instead, because of the "widespread temperature impairments and common source factors within the North Coast Region" [and the Eel River], the Regional Board began developing a region-wide approach for addressing temperature issues (NCRWQCB 2013). Meanwhile, six environmental organizations sued the State and Regional Water Boards for failing to develop temperature TMDL implementation plans for the Eel, Mattole, and Navarro River watersheds. The suit resulted in a stipulated agreement in which the Regional Water Board agreed to develop stand-alone TMDL implementation plans for the three watersheds concurrent with the development of the region-wide policy.

The region-wide approach was first articulated in Order No. R1-2012-0013, *Policy Statement for Implementation of the Water Quality Objective for Temperature in the North Coast Region* (2012). The Order directs Regional Water Board staff to incorporate the Policy into the *Water Quality Control Plan for the North Coast Region* (Basin Plan). The Regional Water Board adopted the *Policy for the Implementation of the Water Quality Objectives for Temperature* and *Action Plan to Address Elevated Water Temperatures in the Eel River Watershed* (Temperature Policy) into the Basin Plan In March 2014. The Eel, Mattole, and Navarro rivers temperature TMDL implementation plans follow the approach articulated in the region-wide Policy.

The Temperature Policy provides for a broad-based approach to temperature control, relying on existing authorities and mechanisms; it reiterates the linkage among temperatures, solar radiation, and stream shade presented in north coast temperature Total Maximum Daily Loads (TMDLs); it directs the incorporation of shade considerations in permits (i.e., waste discharge requirements, waivers, 401 certifications, and NPDES permits) and regional nonpoint source programs as appropriate; and it affirms the need to work with other agencies to address water temperatures on a region-wide basis to reduce impairments and prevent further impairment. The Temperature Policy is intended to address three primary water quality factors that influence temperature: shade, sediment, and flow. The Temperature Policy also directs the Regional Water Board to develop region-wide temperature trend monitoring and implementation work plans. The temperature trend monitoring plan and temperature implementation work plan have yet to be developed, but are expected to have basin-specific elements (McFadin, pers. comm. 2013).

The Temperature Policy recognizes the site-specific nature of water temperature considerations, and directs Regional Water Board staff to address temperature factors appropriately when implementing permits. The Temperature Policy establishes a goal of restoring and maintaining riparian shade, but acknowledges that situations exist where a short-term reduction of shade is acceptable to achieve a long-term benefit. The *Staff Report Supporting the Policy for the Implementation of the Water Quality Objectives for Temperature and Action Plan to Address Temperature Impairment in the Mattole River Watershed, Action Plan to Address Temperature Impairment in the Navarro River Watershed, and Action Plan to Address Temperature Impairment in the Eel River Watershed* specifically identifies restoration and fuel load reduction projects as examples of such situations. The Temperature Policy and related documents can be viewed at:
http://www.waterboards.ca.gov/northcoast/water_issues/programs/basin_plan/temperature_amendment.shtml

Additional Impairments Aluminum, Dissolved Oxygen, and Mercury

Within the all of the forks and tributaries of the Eel River, there are the following impairments: Aluminum (Middle Fork Eel River, South Fork Eel River, Mainstem and Lower Eel rivers); Dissolved Oxygen (Lower Eel River); and Mercury (Upper Mainstem Eel River). State and Regional Water Board staff is developing a statewide water quality control program for mercury that will include a mercury control program for reservoirs and mercury water quality objectives. Aluminum impairment is not currently scheduled for a TMDL and is likely from a geologic source as it appears to be closely tied to sediment loading (Carter, pers. comm. 2014). The dissolved oxygen impairment in the Lower Eel River is not currently being studied nor is it being scheduled to be studied by the Regional Board (Carter, pers. comm. 2014). According to the State Water Resources Control Board Dissolved Oxygen Fact Sheet 3.1.1.0, low dissolved oxygen is generally caused by increases in water temperature, algal blooms, human waste, and animal waste.

Nutrient Assessments/Studies

There are no nutrient related impairments on the 303(d) list for any of the forks or tributaries of the Eel River. The Surface Water Ambient Monitoring Program (SWAMP, see section with same name below for more information) of the State Water Quality Control Board is compiling nutrient data for the Eel River that will be available on the database CEDEN in early 2015 (McFadin pers. comm. 2014). In addition to the State's effort there are the citizen-based (ERRP) and university-based (UC Berkeley) nutrient monitoring data for portions of the Eel River.

Historically, Eel River salmon and steelhead released mass quantities of nutrients, energy, and other essential biomolecules into their natal watersheds through the process of reproduction. These salmon-derived materials (marine-derived nutrients) support the productivity of freshwater and riparian food webs through release of eggs and carcass decomposition and promote both primary and secondary productivity and ultimately juvenile salmonid growth (Bilby et al. 1996, Schindler et al. 2003, Kiffney et al. 2014). The loss of marine-derived nutrients in Eel River watersheds is considered a water quality issue by the SONCC coho salmon recovery plan (NMFS 2014); since salmonid spawning populations are severely reduced which has likely resulted in resource limitations for salmonid-rearing food webs. Additions of salmon carcasses and carcass analogs (pasteurized pellets formed from adult salmon) to streams has resulted in increased food web productivity, including juvenile salmonid growth (Claeson et al. 2006, Janetski et al. 2009, Kohler et al. 2012, Kiffney et al. 2014).

Cyanobacteria (blue-green algae)

Cyanobacteria (blue-green algae) are photosynthetic bacteria that are distributed globally in freshwater, saltwater, and terrestrial environments. Several genera of cyanobacteria grow in the Eel River: Anabaena, Phormidium, Oscillatoria, Cylindrospermum, Nostoc, Nodularia, with occurrences of other genera still being documented. These genera are naturally found at low abundance in biofilms on rocks and macroalgae. However, under certain environmental conditions, the cyanobacteria will bloom, forming benthic mats growing on cobbles or epiphytically on green filamentous algae. Unlike the Klamath River, there are no planktonic blooms of cyanobacteria in the Eel River.

Exposure to cyanobacteria and their toxins can pose risks to humans, pets, livestock, and wildlife. There are many different cyanotoxins produced by cyanobacteria (microcystins, anatoxin-a, nodularin, cylindrospermopsin, etc.). In California, two frequently monitored cyanotoxins are the liver toxin, microcystin, and the neurotoxin, anatoxin-a. Exposure may occur by ingestion, dermal contact, or inhalation. Risks to people may occur when recreating in water where a cyanobacteria bloom is present, or from consuming drinking water that uses a surface water source with elevated cyanotoxin concentrations. Depending on the toxin, exposure to cyanobacteria can cause rashes, skin and eye irritation, gastrointestinal upset, and other effects. At high levels, exposure can result in serious illness or death. Since cyanotoxin molecules remain inside the cyanobacterial cells, ingestion of algal cells is usually necessary to be exposed to high doses of toxin molecules. However when an algal bloom is senescing, then more toxin molecules are released into the water column as the cells walls break apart. This may result in increased concentrations of the toxin in the water column. Chronic effects of low dose exposure to microcystins seem to affect liver function, but are not well understood (USEPA 2012). However, microcystins are identified by the USEPA as potential tumor promoters.

Of the several dog deaths attributed to cyanotoxins in the Eel River, most of the dogs showed symptoms of anatoxin-a poisoning (Puschner et al. 2008, Backer et al. 2013). Monitoring data from summer 2013 showed higher levels of anatoxin-a in the water than microcystin (Bouma-Gregson, unpublished data). Evidence is mounting that anatoxin-a is the more prevalent cyanotoxin in the watershed. Many different species of blue-green algae can produce cyanotoxins. However, not all individual cells in a species will produce the toxin. Therefore, field and microscope observations alone can only determine if "potentially toxic cyanobacteria" is present at a site or in a sample. Only with laboratory analysis can toxin production be identified and quantified.

Potential environmental drivers of benthic cyanobacteria mats are temperature, nutrients, and flow regime. In warmer temperatures, cyanobacteria grow faster than other algal taxa, especially diatoms. Some cyanobacteria species are also able to fix nitrogen from the atmosphere or grow faster at higher nutrient concentrations. The small cell size of cyanobacteria means they have faster nutrient uptake rates and may perform better in slow flowing waters when nutrient delivery rates are low. As of 2014, no experiments have been conducted to identify causal relationships between environmental drivers and cyanobacteria proliferations in the Eel River. However, it is likely that flow could have a significant effect on cyanobacteria growth rates because flow affects several other environmental variables, such as temperature and nutrient delivery. Because flow controls the abiotic environment algae experience, changes in flow may have a large affect on the species composition of algal assemblages.

A draft voluntary state-wide guidance document *Cyanobacteria in California Recreational Water Bodies: Providing Voluntary Guidance about Harmful Algal Blooms, Their Monitoring, and Public Notification*

(CDPH, July 2010 Draft) is available on the CA DPH website at:
http://www.cdph.ca.gov/HEALTHINFO/ENVIRONHEALTH/WATER/Pages/Bluegreenalgae.aspx

Surface Water Ambient Monitoring Program (SWAMP)

SWAMP is a State Water Resources Control Board monitoring program tasked with assessing water quality in California's surface waters (see also Chapter 8: Monitoring). The program conducts monitoring directly and through collaborative partnerships, and provides information to support water resource management in California. California SWAMP was created to fulfill the State Legislature's mandate for a unifying program that would coordinate all water quality monitoring conducted by the State and Regional Water Boards. In addition, SWAMP promotes collaboration with other entities by proposing conventions related to monitoring design, measurement indicators, data management, quality assurance, and assessment strategies, so that data from many programs can be used in integrated assessments that answer critical management questions.

SWAMP monitoring evaluates the physical, chemical, and biological integrity of the State's waters. Regardless of scope, all effective monitoring programs are designed to answer specific assessment questions asked by resource managers. SWAMP statewide and regional monitoring programs are each designed to address one or more of the following assessment questions for defined water body types and beneficial uses:

- Status: What is the overall quality of California's surface waters?
- Trends: What is the pace and direction of change in surface water quality over time?
- Problem Identification: Which water bodies have water quality problems and which areas are at risk?
- Diagnostic: What are the causes of water quality problems and where are the sources of those stressors?
- Evaluation: How effective are clean water projects and programs?

The SWAMP program's Status and Trends Monitoring Program in the North Coast Region was designed to rotate intensive monitoring through watersheds on a five-year cycle, as well as sample permanent long-term stations on a quarterly basis. Those data include typical water quality constituents such as dissolved oxygen, minerals, nutrients (nitrogen and phosphorus), and heavy metals, as well as pesticides in specific instances. This program operated from 2001-2013, but is currently suspended.

In March 2008, NCRWQCB SWAMP staff issued a report, "Summary Report for the North Coast Region (RWQCB-1) for years 2000-2006", of the data collected by the status and trend monitoring program. The report demonstrated that, in general, the water quality conditions in the north coast region were mostly of sufficient quality to meet most of the beneficial uses as outlined in the Basin Plan. However, data collected did not provide sufficient information for current 303(d) listed waterbodies to be delisted, and instead added five new waterbodies to the 303(d) list for impairments due to excess water column aluminum concentrations. These waterbodies were the Lower Eel River, Middle Fork Eel River, Middle Main Eel River, South Fork Eel River, and Gualala River.

Beginning in 2008 through 2013, the NCRWQCB determined that the Regional SWAMP Program should expand the monitoring efforts to include "site-specific" monitoring to document ambient water quality conditions in potentially clean and polluted areas and provide data to evaluate the overall effectiveness of our regional water quality regulatory programs, while still maintaining the Status and Trend Monitoring Program. The Status and Trends Monitoring Program has visited various sites within the Eel

River watershed in every year from 2001 through 2011. In addition, the NCRWQCB SWAMP program conducted a nutrient study in 2010 of the middle South Fork Eel River with sites located from Redway through Myers Flat. The Statewide SWAMP Program has monitored several sites between 2008 and 2011 as part of the statewide Perennial Streams Assessment (PSA) and the Reference Condition Monitoring Program (RCMP).

Eel River Recovery Project (ERRP)

The Eel River Recovery Project is a citizen-based watershed monitoring and education group dedicated to cleanup and improvement of the Eel River (see also Chapter 8: Monitoring, and Chapter 9: Community Engagement and Information-Sharing). Founded in 2011, ERRP has recruited community members, Tribes and government agencies to collaborate on on-the-ground monitoring and data collection, primarily focused on water temperature monitoring, field observation of blue-green algae, and documenting the early stages of the fall-run Chinook salmon run. ERRP has organized and hosted several community outreach and education events, including three annual Water Days, to bring technical and regulatory information to the public.

Sub-committees are currently tackling coordination with agencies and Tribes, community education, media outreach, citizen water quality monitoring, water conservation, algae suppression, boating events, and river cleanup. An important factor in their success is their ability to gain access through private property. Numerous residents have engaged as ERRP volunteers, allowed access to their properties, and joined us in the field to collect scientific data and establish photo-monitoring sites. Citizen monitoring is being used to supplement data from public agencies and can also be used for trend monitoring and to help assess effectiveness of restoration. A presentation to the Eel River Forum in November 2012 described the past and ongoing monitoring efforts by ERRP (Desmond 2012). Several reports by ERRP (Higgins 2011, 2012, 2013) are available online at http://www.eelriverrecovery.org

Proposed Actions for Eel River Forum

1. Expand water temperature monitoring in priority areas, particularly sub-watersheds and stream reaches that currently support abundant coho salmon runs. For water quality monitoring expansion, the Eel River Forum needs to work with the Regional Water Board TMDL program and the State Water Board's Citizen Monitoring Program to implement standardized monitoring protocols. Monitoring data needs to link to the SWAMP program and the California Environmental Data Exchange Network (CEDEN database).

2. Support ERRP efforts to expand citizen-based monitoring of water temperature and blue-green algae. The ERRP's largely volunteer effort has demonstrated the ability to collect valuable real-time data that can be used to supplement ongoing agency monitoring programs, particularly reaching locations inaccessible to agency personnel. ERRP should pursue efforts to collect temperature data at sites monitored previously (e.g., late 1990's surveys by Humboldt County Resources Conservation District), allowing a comparison of current conditions to those from the mid to late 1990's.

3. Investigate temperature restoration opportunities. Use TMDL shade model results to investigate riparian restoration opportunities. Shade modeling work that was completed for Eel River TMDLs estimated both current and potential shade conditions, based on vegetation information. Significant differences between current and potential shade conditions may represent potential opportunities for canopy restoration to support cold water.

4. Support expansion and continuation of SWAMP monitoring to track nutrients, cyanobacteria, and algae in selected Eel River locations.

5. As a means to increase instream flows during the summer low-flow season and thus reduce summer water temperatures, prioritize winter off-channel water storage within Regional Board temperature TMDL programs (e.g., USEPA 319h funding).

6. Provide input to the Regional Water Board on the contents of the temperature trend monitoring plan and temperature implementation work plan.

7. Support ERRP as they seek to expand it's their water quality monitoring program through grant funding support.

8. Request that Van Duzen be officially recognized as impaired for temperature to match USEPA/SWRCB's prioritization for restoration with the other six subbasins.

9. Establish a tiered cyanobacteria monitoring program. With minimal training, identifying macroscopic mats of cyanobacteria is possible. Using a tiered approach, staff from agencies or citizen volunteers could document the presence/absence of cyanobacteria mats at specific monitoring sites throughout the watershed. Only if cyanobacteria were identified as present, then samples could be collected and sent off to labs for more thorough species and toxin analyses.

10. Provide educational materials for the public and agencies. Currently there is a limited amount of information about the characteristics of cyanobacteria in the Eel River. Between UC Berkeley and the Eel River Recovery Project, the amount of observational information that could be compiled into a website or document is increasing. This could then be made available to the public, agencies, and NGOs to inform them about how to identify and avoid cyanobacteria in the Eel River.

11. Integrate algal and cyanobacterial sampling into other research and monitoring projects. Knowledge of the spatial distribution of cyanobacteria in the Eel River is still limited. Incorporating cyanobacterial data collection into other fish and water quality research programs would provide valuable information. Examples include collecting benthic algal samples, recording observational data of algae and cyanobacteria, or collecting water samples for cyanotoxin analysis.

12. Initiate experiments to understand cyanobacterial ecology in the Eel River. Implement manipulative experiments in the field and lab to identify the effect of different environmental variables on the physiology and ecology of cyanobacteria.

13. Assess feasibility and develop plan to supply appropriate amounts of marine-derived nutrients (through carcass analogs) to streams in order to increase growth and survival of juvenile salmonids. Effectiveness monitoring could include nutrient concentrations in water (total and dissolved nitrogen and phosphorus); periphyton and invertebrate productivity; salmonid growth, biomass and smolt production; and the stable isotopes of carbon and nitrogen, which provide a tracer for salmon-derived nutrients.

4: SEDIMENT IMPAIRMENT AND TMDL IMPLEMENTATION

Summary of the Issue

The discharge of excessive sediment into watercourses from hillslopes and unimproved road networks has caused severe impairment to many watercourses and watersheds in the Eel River. According to Lisle's (1978) oft-quoted statement, the Eel River has "the highest recorded average suspended sediment yield per drainage area of any river of its size or larger unaffected by volcanic eruptions or active glaciers in the conterminous United States (1,720 t/km^2/yr from 9,390 km^2; Brown and Ritter, 1971)." Lisle attributes high rates of erosion and sediment transport to a unique combination of highly active tectonics, the highly erosive Franciscan bedrock underlying most of the basin, high seasonal rainfall and intense storm events, and widespread anthropogenic disturbance of the ground surface in the last century and a half. Naturally high sedimentation rates have been well-documented in the Eel River, and increased delivery and storage of sediment in stream and river channels has been accelerated during the past 150 years by numerous anthropogenic causes: forest management and timber harvesting activities, road construction, agriculture, urban stormwater runoff, and more recently by marijuana production. These human activities have had major impacts on forest and aquatic ecosystems and have impacted habitat essential to salmonid spawning, early development, fry and juvenile rearing life stages.

Many decades of studies, published literature and reports have demonstrated that the discharge of excessive sediment to streams and rivers damages pool habitat, degrades spawning gravel, reduces permeability and water exchange in redd egg pockets, impairs benthic invertebrate riffle habitat and productivity and thus reduces salmonid food resources, reduces hyphorheic flows, increases suspended sediment and turbidity, and increases water temperatures. Instream habitat degradation also extends beyond salmonids to numerous other fish, amphibian, bird, wildlife, and invertebrate species. Many other negative effects not listed here may also be attributed to increased sedimentation of streams and rivers.

Roads associated with rural homesteads, ranching, and more recently marijuana cultivation, are major contributors to sediment loads in the Eel River watershed. As lands in the Eel River basin were subdivided from timber and ranch lands into smaller parcels now used for homes, the amount and use of roads in the watershed increased. Residents developing home sites often used the old logging and ranching roads for access to their property. Sometimes residents used old skid roads as driveways and old landings for home sites. Impacts to fish from these roads come in two forms: chronic surface erosion of fine-grained material during winter rainstorms that reduce the survival of fish eggs, and catastrophic failure of road prisms during heavy storms that cause the potential loss of habitat for summer rearing. Many of these roads were built for temporary logging usage and were not designed for long-term use. Many other roads have been recently constructed to afford access to home sites or other sections of a parcel, often without knowledge of proper design. Often the design of road drainage into ditches and culverts is poor and creates chronic problems that require frequent maintenance and further erosion of hillslopes. Landowners sharing a common road regularly form agreements for road maintenance. However, road maintenance is quite expensive, requires the use of heavy equipment and often the importing of durable rock, and thus is difficult for some residents to afford. In some counties, regulations are in place for road grading, but these regulations are not enforced and few people are aware of them. In addition, pollutants such as gasoline, oil, and radiator fluid leak onto road surfaces and then can be washed into streams during rains.

Fortunately, sediment sources and hillslope erosion and delivery processes are comparatively easy to identify and quantify, and restoration treatments are straightforward and have become increasingly effective as restoration practices have evolved. Additionally, state and federal resource agencies (including CalFire, CDFW, NMFS, USFS, and NCRWQCB) have focused extensively on this issue and have made more resources available. Two primary regulatory venues have been used to address sediment problems in north coast watersheds – the forest practice rules promulgated by the State Board of Forestry, and the Clean Water Act 303d listing and TMDL process overseen by the Regional Water Board. A brief summary of the current status of these regulatory programs is provided here. The CDFW Fisheries Restoration Grants Program (FRGP) has also focused considerable resources on sediment remediation on both private and public lands in the Eel River. These efforts to reduce impacts of excess sediment are detailed below.

California Board of Forestry's Forest Practice Rules

Management of timber harvesting has long been a source of controversy in the north coast region. In 1973 California passed the Z'berg-Nejedly Forest Practice Act (FPA) to regulate logging on private and corporate land in California. The FPA created the 9-member Board of Forestry (BOF) appointed by the Governor and established the Forest Practice Rules (FPRs) to provide standards for forestry management and environmental protection. (California Board of Forestry website: http://www.bof.fire.ca.gov/). The California Department of Forestry and Fire Protection (CalFire) is designated as the lead agency responsible for overseeing the FPRs.

The FPRs were frequently debated as to their adequacy in protecting watersheds and anadromous salmonid populations, but with the proposed and eventual listings of anadromous salmonids, the FPRs came under increased scrutiny in the late 1990s. In 1996, the NMFS proposed to list the Northern California steelhead ESU as threatened under the ESA, but deferred the final listing determination pending the outcome of conservation measures proposed by California. Those conservation measures were specified in a joint NMFS-CA 1998 Memorandum of Agreement (MOA), and related primarily to "several provisions calling for the review and revision of California's Forest Practice Rules (FPRs), and a review of their implementation and enforcement by January 1, 2000" (NMFS 2000 Final Rule 65FR36074). The state and federal MOA specifically addressed steelhead in the Northern California and Klamath Mountains Province ESUs within California. As part of the 2000 MOA, the State agreed to organize an independent Scientific Review Panel (SRP) to undertake a comprehensive review of the California FPRs, particularly with regard to their adequacy for protection of salmonid species.

The Scientific Review Panel was formed, conducted its review of the FPRs, and released its *Report of the Scientific Review Panel on California Forest Practice Rules and Salmonid Habitat* (Ligon et al. 1999). The SRP report focused on watercourse protection measures, road construction and maintenance, and winter operations limitations. The SRP reviewed Timber Harvesting Plan (THP) implementation issues, especially RPF involvement throughout the THP process as well as THP review and approval procedures, and developed recommendations for improving this process. The SRP's primary conclusion was that the FPRs did not ensure protection of anadromous salmonid populations due to the "lack of a watershed analysis approach capable of assessing cumulative effects attributable to timber harvesting" (Ligon et al. 1999). Based in part on the scientific review panel report and findings in 1999, the California Resources Agency and CalEPA jointly presented BOF with a proposed rule change package designed to address shortcomings in the State's existing FPRs. The BOF circulated the proposed rule package for public review, held several meetings and two public hearings, but failed to take action to adopt any of the proposed FPR changes.

In 2004, the BOF put in place interim "Threatened or Impaired Watershed" rules (T/I Rules). The T/I Rules established requirements for Timber Harvest Plan disclosures and operational practices permitted under the FPRs for commercial timber harvesting on private lands where state or federally listed anadromous salmonid species (coho salmon, Chinook salmon and Steelhead) were present or could be restored. In 2006, the BOF appointed a Technical Advisory Committee (TAC), to review the T/I Rules. The TAC's primary charge was to organize a literature review, ensure the literature review was adequately completed, and advise the Board on its findings.

At the conclusion of this review process in 2010 the BOF approved the Anadromous Salmonid Protection rules (ASP rules), which became effective January 1, 2010. The ASP rules are intended to protect, maintain, and improve riparian habitat for state and federally listed salmonids. The Board's primary objectives in adopting the ASP rules were: (1) to protect and restore habitat conditions for coho salmon and other anadromous salmonids in California river systems, (2) to increase fish population abundance, (3) to improve the conservation status of threatened salmonid species, and (4) to meet Public Resources Code §4553 for review and periodic revisions to FPRs. The main goals of the Board for the rule revisions included having an update based on science; providing a high level of protection for listed species; having rules that contribute to anadromous salmonid habitat restoration; having consistency with partner agency mandates; and promoting landowner equity, flexibility and relief opportunities (BOF-CalFire 2008).

While the ASP rules provide improvements to the FPRs for the protection of listed salmonids, several shortcomings have been identified, including inadequate riparian canopy retention standards in non-fish bearing streams outside the FPR defined "zones of anadromy" to ensure protection of all Beneficial Uses of Water, allowances for increased harvest activities closer to watercourses, and the lack of watershed-wide analysis of cumulative effects including watershed-scale rate of harvest evaluations to protect waterbodies from impairment.

Regional Water Board TMDL Implementation

A Total Maximum Daily Load is a calculation of the maximum amount of a pollutant that a body of water can receive and still safely meet water quality standards. Regional Water Board (NCRWQCB) staff engineers presented an overview of the Regional Board's sediment and temperature TMDL policies and activities in the Eel River (McFadin and Geppert, February 2013). The following is a summary of information presented to the Eel River Forum.

The Regional Board defines a sediment impaired water body as one that "does not meet sediment-related water quality objectives or does not support beneficial uses because of too much sediment." These water bodies are listed on the federal Clean Water Act Section 303(d) List of Impaired Water Bodies. All seven Eel River sub-basins are listed on the CWA 303(d) list as impaired due to excessive sediment. TMDL allocations were established by the USEPA for each sub-basin over an eight year period from 1999 to 2007, including the Van Duzen River (1999), South Fork Eel River (1999), North Fork Eel River (2002), Middle Fork Eel River (2003), Upper Mainstem Eel River (2004), Middle Mainstem Eel River (2005), and the Lower Mainstem Eel River (2007).

Eel River TMDL sediment analyses were developed using aerial photo analysis (large landslides), modeling (road surface erosion), and erosion surveys in random plots. Sediment analyses identified roads (surface erosion, crossings, slides, gullies) and timber harvest (slides, skid trails) as primary anthropogenic sediment sources. Impacts of cattle grazing on sediment production were found to be minimal (<1%).

The State Water Board and Regional Water Board have developed and adopted several Policies for sediment (and temperature) as part of its *Water Quality Control Plan for the North Coast (Basin Plan)*. TMDL Policies include:

Nonpoint Source Policy (2004): The Nonpoint Source (NPS) Policy was adopted by the State Water Resources Control Board in 2004. This policy abandoned the "self-directed compliance" and instead directed the Regional Boards to regulate nonpoint sources through waste discharge requirements (WDRs), conditional waivers of WDRs, prohibitions, or certified third-party programs.

Sediment TMDL Implementation Policy (2004): The Sediment Implementation Policy directs staff to set watershed priorities for addressing sediment waste discharges at a watershed-specific level, and describes how and when prioritized actions will be taken throughout the North Coast Region. In addition, the Sediment Policy directs staff to:

- Rely on regulatory authorities including standard setting, permitting, and enforcement
- Rely on non-regulatory actions: grants, third party programs, MOUs, outreach and education
- Develop a workplan, guidance documents, monitoring strategy, and prioritize watersheds

The Regional Water Board's 2008 Sediment Work Plan describes current activities and planned tasks to control excess human-caused sediment. Task completion is dependent on resource availability (NCRWQCB staff). The Sediment Work Plan contains:

- Regional Tasks
- Watershed Tasks
- Priority Rankings for each Regional Task
- Priority Rankings for each Watershed
- Schedule / 10-year Time Frame
- Resource Needs: 19 additional staff needed.

Sediment monitoring plans have not been developed for the Eel River.

There are currently 21 Regional Water Board staff currently working on sediment issues. Eel River sub-basins were not listed as high priority, ranking from 8 to 17 out of 17. However, the lower mainstem Eel River has been on the USEPA/ NCRWQCB priority list for implementation funds, and the South Fork Eel River was added to the list in 2013. Implementation of the sediment TMDL has been fairly extensive in the Eel River, and in the North Coast Region in general. The Regional Water Board has used several implementing mechanisms, including:

- Timber harvest regulatory program[1] for THP and Non-Industrial Timber Management Plans in the Eel River watershed focuses on:
  - The prevention and minimization of sediment from new potential sources associated with conducting timber harvesting activities through a variety of design measures including silvicultural and yarding methods as well as the timing and location of operations,
  - The identification, prioritization, and treatment of existing and threatened discharges from existing sources defined as Controllable Sediment Discharge Sources sites in the implementation of Erosion Control Plans,

[1] http://www.swrcb.ca.gov/northcoast/water_issues/programs/timber_operations/

- Development of fuel management plans, and
- Implementation of monitoring and reporting programs that require harvest plan monitoring prior to and during the winter to assess erosion control measures were installed per plan specification and assess effectiveness.

- U.S. Forest Service. Program[2] focuses on the preventing and minimizing of waste discharges through the implementation of a variety of federal policies and guidelines directing project planning and erosion control measures and relies heavily on existing programs within the Forest Service utilizing Best Management Practices (BMPs). The Forest Service program implements, in part, the assessment and prioritization of restoration priorities and monitoring programs to meet the watershed protection goals of the Northwest Forest Plan. The Categorical Waiver covers a variety of activities including:
    - Timber harvesting related activities,
    - Maintenance, construction, upgrades, storm-proofing, and decommissioning of roads,
    - Grazing,
    - Fuel management and vegetation manipulation,
    - Restoration activities such as road decommissioning, instream habitat improvements, and forest rehabilitation,
    - Fire suppression, and
    - Recreation activities including use of trails for off-road vehicles.

  Note: Mining activities are not covered under the Categorical Waiver.
- California Department of Transportation (Caltrans). The Caltrans permit for storm water discharges National Pollution Discharge Elimination System (NPDES) permit, Order No. 2012-0011-DWQ, covers storm water discharges from all Caltrans owned Municipal Separate Storm Sewer Systems (MS4s), vehicle maintenance, equipment cleaning operations facilities and any other facility with activities that have the potential of generating significant quantities of pollutants, and certain non-storm water discharges.
- Five Counties Road Management and Activities. In May 2013, the North Coast Regional Water Quality Control Board adopted Order No. R1-2013-0004, Waiver of Waste discharge Requirements and General Water Quality Certification for County Road Management [3]
- California State Parks. The State Parks have been engaged in a variety of sediment reduction activities over the course of the past decade and a half. Projects have included inventorying sediment sources, road rehabilitation and decommissioning, instream habitat projects. Plans to do floodplain reconnection and restoration are also of interest and priority to the Park. Currently, most of the State Park projects are covered by the National Pollution and Prevention Discharge System (NPDES) Storm Water Permitting Program. State Parks has inventoried abandoned and service roads in most of the major watersheds that it owns and manages in the South Fork Eel River (Humboldt Redwoods State Park, including Bull Creek, Canoe Creek, Mail ridge (partial); Richardson Grove State Park (Durphy Creek); Standish Hickey State Recreation Area (Mill Creek); Sinkyone Wilderness State Park (Indian Creek, which drains a minor portion of SWSP to the Eel River basin). Road treatment mileage since about 1997 that affects the Eel River is as follows: Humboldt Redwoods State Park- 75 miles, nearly all in Bull Creek, this is about 35-45% of the needed road treatment for Bull Creek; Standish Hickey State Recreation Area- 7 miles; Sinkyone Wilderness State Park portion within the Eel River basin- 5 miles; Benbow Lake State Recreation Area- 0.1 mile. This work was part of California

[2] http://www.waterboards.ca.gov/northcoast/water_issues/programs/timber_operations/timber_waiver/#r1-2010-0029
[3] http://www.waterboards.ca.gov/northcoast/water_issues/programs/non_point_source/5C/

State Parks' commitment to restoration and enhancement of subwatersheds within their ownership prior to the TMDL process, and is listed here as a complementary effort.

The Regional Water Board has also identified several implementation gaps, which include:

- Activities on Federal lands under the Bureau of Land Management.
- Private rural roads not associated with waivers or WDRs (e.g. rural residential, ranch, and timberland roads not associated with a timber harvest plan or non-industrial timber management plan) - Regional Water Board staff are currently developing an implementation approach to address such roads. Using a partnership and outreach strategy and not necessarily a permitting strategy, the Rural Roads Education and Outreach Program (Rural Roads Program) will be a critical step in beginning to address this significant source of NPS pollution in the North Coast Region.
- Compliance - Regional Water Board staff have expressed there are insufficient staff resources to adequately ensure compliance with existing programs with water quality standards and address implementation gaps.

Current Status of Sediment Reduction Efforts

The sediment issue in the Eel River is challenging because of the size of the watershed and immense scale of the degradation, the relatively high cost to treat erosion and excessive stored sediment problems, and the large time commitment required to accomplish meaningful and measurable recovery. The two regulatory programs/processes described above are addressing the primary causes of excessive sedimentation in the Eel River as thoroughly as possible with available resources. However, continued implementation of sediment reduction projects begs the question: How much real progress has been made in reversing sediment impairment? To what extent have sediment reduction efforts implemented under the revised FPRs and the NCRWQCB's TMDL programs met targets, goals, and objectives of resource managers? In the Eel River, these key questions have yet to be answered.

A good example of a north coast watershed in which answers to these questions are being pursued is Redwood Creek, the watershed encompassing Redwood State and National Parks. Redwood Creek is a 280 mi^2 watershed, less than 8% of the Eel River basin area. The Redwood Creek Watershed Group and Redwood State and National Park scientists have made a notable effort to demonstrate the financial investment and restoration effort required to make significant progress in sediment reduction (Figure 7). According to Bundros and Short (2011) "Cooperative

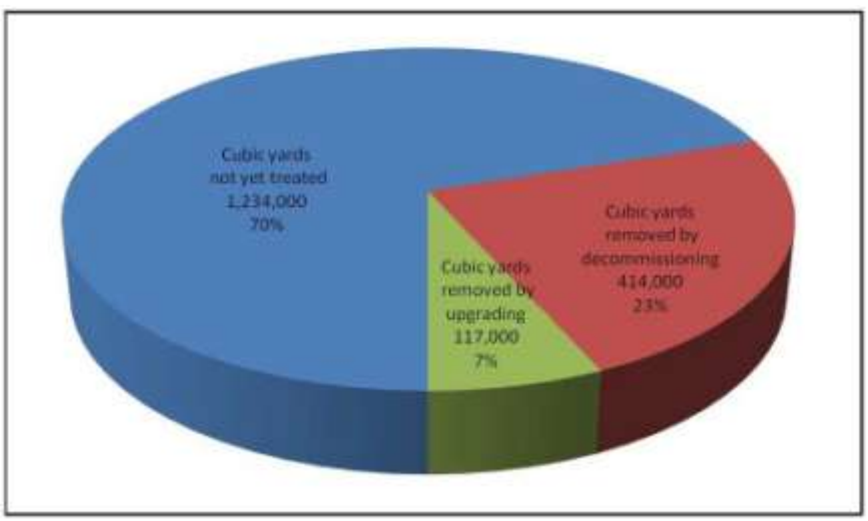

Figure 7. Overall progress in sediment reduction efforts in Redwood Creek, CA (Bundros and Short, 2011.)

efforts to control and prevent erosion from logging roads in the upper Redwood Creek watershed (areas upstream of the park) started in earnest in 1996." The analyses presented in their report were based on work completed through 2009, thus spanning 14 years of implementation effort. In summary:

- "About 120 miles [of roads] have been upgraded and about 61 miles have been decommissioned.
- "…road treatments have reduced the potential sediment yield from logging roads in the upper watershed by about 531,000 cubic yards. This is about 30 percent of the potential sediment yield estimated at assessed sites or about 19 percent of the estimated total for the upper watershed.
- "Completed work has reduced potential sediment loading by about 36 percent of the TMDL's required 60 percent load reduction. However, 71 percent of the total reduction occurred in the lower watershed, on park lands, compared to a 29 percent reduction in the upper watershed, mostly private lands. While both represent significant reductions, more work is needed in the upper watershed to more fully distribute load reduction throughout the watershed.
- "Total funding for all cooperative erosion control projects in the upper watershed through 2009 was about $5.8 million. Landowners have contributed about 33% of the funds.
- "For watershed recovery, the work is necessary and achievable."

(Bundros and Short, 2011.)

The Yager/ Van Duzen Environmental Stewards (YES) have enacted a successful approach to community and watershed-scale response to sediment impairment, the NCRWQCB TMDL listing, and the potential for increased regulatory burden. YES is a collaborative group of ranching landowners who occupy the middle portion of the Yager Creek watershed, and who have taken a proactive approach to salmonid conservation by (1) increasing their technical understanding of the causes and solutions to excess sedimentation, (2) forming partnerships with state and local agencies to successfully address regulatory challenges, and (3) developing and implementing sediment reduction projects and BMP's to minimize impacts on sediment and water quality (Figure 8). In 2003, YES and Pacific Watershed Associates conducted a Watershed Assessment and have implemented six road sediment reduction grant projects through 2011. In addition, the YES community group has also:

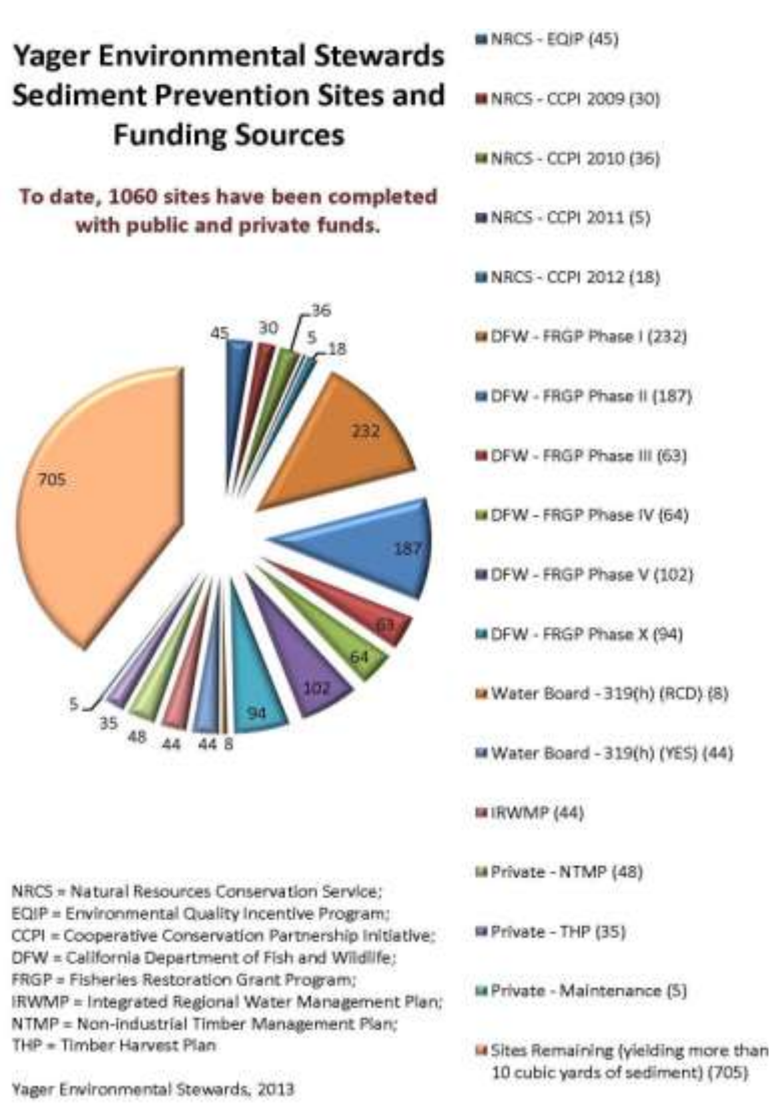

Figure 8. Overall progress in sediment reduction efforts in Yager Creek, CA (Yager Environmental Stewards 2012)

- Developed grazing systems to protect soil conditions,
- Placed fencing to protect watercourses from cattle grazing,
- Developed livestock watering systems to protect riparian areas,
- Located minerals and supplemental feeds away from riparian areas and watercourses,
- Upgraded ranching roads to mitigate sediment delivery and improve drainage,
- Developed YES Ranch Road Maintenance protocols that include annual inspection and maintenance, and
- Implemented photo and topographic monitoring on upgraded road systems.

Integral to this work is the technical expertise that has been developed in the past several decades in sediment source assessment, watershed restoration, and erosion control for protection of upland salmonid habitat. Information presented to the Eel River Forum at the February 2012 meeting by Pacific Watershed Associates (PWA) engineering geologist Tom Leroy demonstrated the technical capabilities of local restoration practitioners to implement practical, science-based solutions. In addition to the Yager Creek/ Van Duzen River watershed, PWA is planning and implementing innovative sediment reduction efforts in several sub-watersheds of the South Fork Eel River, including Hollow Tree, Standley, Indian, Piercy, Bear Pen, Wildcat, Dutch Charlie, and Redwood creeks. Those projects range from simple site investigations and erosion control projects to large-scale watershed assessments and sediment source investigations, and highly complex restoration and sediment control efforts.

Numerous other groups (including several Eel River Forum members) have been implementing sediment projects for many years, including the Eel River Watershed Information Group, Resource Conservation Districts, Humboldt Redwood Company, Mendocino Redwood Company, GDRC, and others. This experience illustrates that land and watershed managers have the necessary technical knowledge and skill, but still need more financial and technical resources than are presently available to make a significant difference in sediment reduction efforts. Given this present situation, strategic planning and implementation based on clear prioritization is greatly needed.

Proposed Actions for Eel River Forum

1. Obtain adequate resources for the Regional Water Board to expand their planning and implementation efforts for sediment TMDL implementation in the Eel River. The Regional Board states they could use 19 additional permanent staff dedicated to implementing sediment reduction efforts. Activities pursued by this staff may include:
    - Development of monitoring plans and programs for collecting and interpreting sediment water quality data;
    - Development of guidance documents and BMP's for private landowners for sediment reduction;
    - Development of TMDL action plans, including sediment and turbidity monitoring, identification and support of sediment source control projects, riparian fencing and revegetation needs.

2. Develop a Road Assessment Database (RAD) (similar to the Passage Assessment Database) and treatment priorities for each sediment impaired Eel River sub-basin. Compile and analyze available data on sediment assessment and reduction efforts completed to-date, including sediment-source inventories, road decommissioning and sediment reduction work completed. Prioritize the next phase of implementation effort on a sub-watershed scale (e.g., HUC-10 units), using a GIS spatial analysis based on density of erosion sites and potential cumulative sediment yield (identifying sediment "hotspots"). Prioritize sub-watersheds using risk analyses, based on erosion threat and risk to salmonid resources.

Other prioritization criteria:

- Large contiguous watersheds managed by a single entity;
- Historic and current abundance of anadromous salmonids and restoration potential;
- Excessive sediment identified as a limiting factor for fisheries recovery and/or an impediment to water quality;
- Residential population and road densities – densely populated rural communities whose year-round road use could result in increased fine sediment loads and chronic impacts are candidates for significant watershed improvement with surface drainage and surfacing improvements;
- Natural sources;

Concentrate sediment reduction efforts in high priority locations to complete all needed sediment reduction work within each sub-watershed in a shorter time period. Allocate annual funding to this effort.

3. Develop a risk-based prioritization of areas for sediment control projects. The risk-based prioritization would take into account where aquatic resources are and their condition (i.e., refugial population, stable population, at risk of extirpation, etc.), as well as the level of threats in upstream areas, such as high/low natural loads, high/low anthropogenic loads, past efforts to address sediment loads, etc. The risk-based prioritization can be used to objectively identify the watershed areas where sediment control projects are most likely to achieve objectives.

4. Develop a guidance document on sediment waste discharge control for use by the public, landowners, organizations, the Regional Water Board and staff, and other agencies involved with sediment control. The following can be used as a model: (1) projects in the Eel River by PWA, ERWIG, and YES, and (2) projects outside of the Eel River which are relevant due to their regional context, including those in Redwood National and State Parks and California State Parks, and information developed by the Redwood Community Action Agency (RCAA) for the Mad River TMDL. This guidance document should include examples of sediment waste discharge sites, sediment control practices, and road management practices; suggested content of a comprehensive inventory of sediment waste discharge sites and a comprehensive erosion or sediment control plan; sediment assessment methods; suggested prioritization criteria; and monitoring guidance (NCRWQCB Sediment policy 2004). Another related consideration is a mandate that a basin-wide erosion control plan be in place for sediment impaired sub-basins.

5. Develop an effective outreach approach to engage private landowners in road-related sediment remediation efforts. The Mattole Restoration Council's 'Good Roads, Clear Creeks' program and Mendocino County RCD's FRGP-funded program could provide useful models or templates for conducting outreach and planning with private landowners to conduct sediment source inventories and prioritize site treatment. The 'Good Roads, Clear Creeks' program works with private landowners to treat sediment sources, integrate design criteria where applicable, design and implement road upgrades and storm-proofing, conduct turbidity monitoring in the post-project phase, and supports sediment modeling. In addition, Pacific Watershed Associates, through grant funding from the State Water Resource Control Board, has recently updated the Handbook for Forest, Ranch, and Rural Roads A Guide for Planning, Designing, Constructing, Upgrading, Maintaining, and Closing Wildland Roads[4]. 319(h) funding could be a possible fit with this landowner engagement effort.

[4] A copy of the this handbook can be located at http://mcrcd.org/publications/

6. Develop a regional sediment monitoring program that fits with available resource levels, and begin implementing a baseline data collection program to establish a mechanism for measuring progress in sediment reduction efforts. Monitoring must link sediment reduction to a biological response, demonstrating improved conditions for beneficial uses. This program should include (1) a database of past and ongoing suspended sediment and turbidity monitoring data from the Eel River, (2) a TSS and turbidity monitoring program at a feasible scale that matches monitoring funding limitations, and (3) a program to survey cross-sections at bridge crossings and other suitable locations to track change (recovery) of coarse sediment. This type of water quality and sediment monitoring is relatively expensive but does not necessitate that data be collected everywhere. Several index sites selected to represent a range of watershed conditions will be useful now and in the future as restoration measures improve sediment conditions.

7. Accelerate sediment remediation and stream channel rehabilitation efforts in the South Fork Eel River's Bull Creek watershed. Bull Creek has not experienced industrial timber harvest since the mid-1960s and is a prime example of a recovering watershed. This entire 42 square mile watershed is publicly owned, has very little human population or development, and thus has great potential to provide high quality instream salmonid habitat. The State Park is preparing for implementation of large-scale floodplain restoration work in several segments of the mainstem Bull Creek. This work should be prioritized for full implementation – the investment will be long-lasting and valuable. The 54-yr streamflow records at the Bull Creek gage (USGS #11476600), and the database developed by State Parks personnel also provide a valuable opportunity for establishing a broad-scale monitoring program in Bull Creek. CDFW's *Coho Recovery Plan* (2004 – section 8.1.11.5) tasks ER-WE-01 and 02 respectively support completion of storm proofing, and habitat enhancement and tree planting in the Bull Creek watershed. In collaboration with CDFW, State Parks developed and has been following upland sub-watershed sediment treatment priorities based on an assessment of the entire Bull Creek watershed.

5: HABITAT RESTORATION AND ENHANCEMENT

Summary of the Issue

Restoration of degraded stream habitats is a critical component of any recovery strategy for the Eel River's natural resources. Stream habitat restoration has become one of the best-developed aspects of salmonid recovery efforts in the Eel River, and is essential to rebuilding salmon and steelhead populations throughout the region. Many Eel River watersheds have been dramatically degraded from a century or more of poor land use practices (see Chapter 1: Introduction). Although conditions in some watersheds (e.g., Bull Creek, Yager Creek, Sproul Creek, Hollow Tree Creek) have improved in response to several decades of regulatory program development, elements of habitat quality remain in decline in many Eel River watersheds.

The North Coast region and the Eel River restoration practitioners have, in many respects, pioneered an industry dedicated to watershed and habitat restoration. Small-scale experimental projects began several decades ago that entailed anchoring wood in streams, replanting conifer forests, and controlling sediment runoff. This industry now provides highly skilled jobs important to the regional economy. Through these efforts, restoration practitioners have advanced to a high level of scientific and technical capability, guided regulatory reform, and developed computer software and database packages. These common practices are detailed in the *California Stream Restoration Manual* (CDFG 2010), which provides the basis for statewide programmatic environmental compliance. Publishing established guidelines has helped the formation of reliable funding programs to annually support habitat restoration efforts (Figure 9).

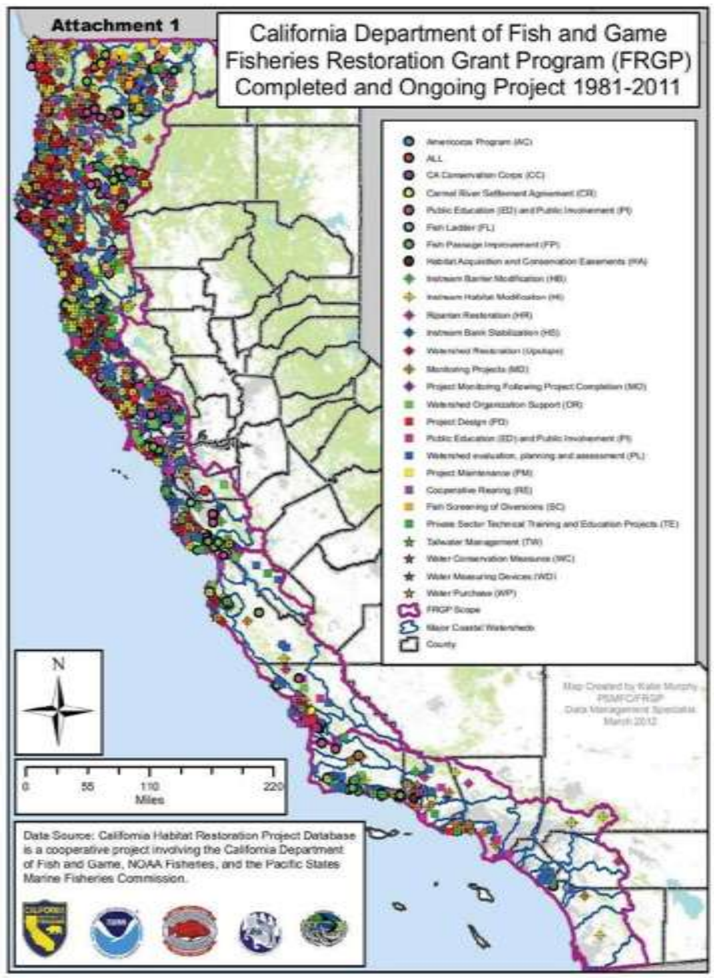

Figure 9. Habitat restoration projects completed throughout California with funding from the Fisheries Restoration Grant Program

The CDFW Fisheries Restoration Grants Program is a multi-agency investment in habitat restoration activities. Traditionally, stream habitat restoration has encompassed four primary areas of practice: 1) sediment reduction, 2) riparian restoration, 3) fish migration barrier remediation, and 4) instream wood placement to improve habitat complexity. The FRGP program began in 1981 and has primarily tackled these four areas of restoration practice since its inception. The program's funding grew in the mid-1990s as result of an infusion of funding associated with the ESA-listing of salmonids (SB271 and the Pacific Coast Salmon Recovery Fund). More recently, FRGP expenditures in the past 14 years have totaled approximately $280 million (CDFW 2013b).

However, in spite of refined techniques and millions spent on habitat restoration, few targeted salmonid populations show signs of recovery. Little restoration effectiveness monitoring data has been collected that links habitat improvements to increased salmonid abundance. Restoration strategies have focused on a relatively limited set of habitat conditions and life history requirements to the exclusion of other critical needs (e.g., streamflow protection). In addition, habitat restoration programs, by virtue of being competitive grant programs, offer a piecemeal approach that spreads limited resources across entire regions. In contrast, The State of Oregon has developed a restoration program that focuses more heavily on individual, high priority watersheds. In the next phase of habitat restoration efforts in the Eel River, restoration practitioners need to bring their individual and collective knowledge and expertise together to help plan and prioritize restoration actions.

Current Status of Habitat Restoration Planning

Some salmonid watershed attribute indicators of concern have been identified by NMFS recovery documents which apply to steelhead, Chinook salmon, and coho salmon (NMFS 2014, 2015a, 2015b). The generalized habitat issues facing the Eel River include the following:

- Estuary: Quality and Extent
- Habitat Complexity: Large Wood & Shelter
- Habitat Complexity: Percent Primary/Staging Pools & Pool/Riffle/Flatwater Ratios
- Hydrology: Baseflow & Passage Flows
- Passage/Migration: Mouth or Confluence & Physical Barriers
- Riparian Vegetation: Composition, Cover & Tree Diameter
- Sediment: Gravel Quality & Distribution of Spawning Gravels
- Water Quality: Temperature

Other watershed attributes, such as turbidity, floodplain connectivity, dams, diversions, and diking only affect some watersheds, or only one salmonid species (but not all). The size of the Eel River watershed (and its problems), and the differing needs for each salmonid life stage make it difficult to prioritize habitat restoration tasks. Habitat trend monitoring is discussed in Chapter 8: Monitoring.

Currently, FRGP funding for habitat restoration is focused on recovery actions identified by SONCC coho salmon recovery plan (NMFS 2014). A much smaller amount of grant funding is available specifically for steelhead through the CDFW Steelhead Report and Restoration Card program. The NMFS recovery documents (SONCC coho salmon recovery plan, coastal multispecies recovery plan draft) assign a priority level for each habitat restoration action using Conservation Action Planning (The Nature Conservancy 2005). The relative importance of each habitat restoration action in turn determines FRGP funding availability for stream habitat restoration projects.

The four primary areas of FRGP habitat restoration have been expanded to include: 5) floodplain and off-channel habitats, 6) thermal refuges and 7) restoring instream flows. These expanded areas are apparent in the 2014 SONCC coho salmon recovery plan, which includes restoration actions fitting these categories. Restoring instream flows is an important component of habitat restoration and is discussed in Chapter 2: Water Resources. Supporting instream flow practices requires a breadth of expertise in training and education, planning and engineering design, regulatory compliance, construction management and implementation, and post-project assessment.

In addition to habitat restoration actions outlined by NMFS salmonid recovery documents, a significant planning effort is currently being conducted by the CDFW Coastal Watershed Planning and Assessment Program (CWPAP). The CWPAP is conducting fishery-based watershed assessments along the length of the California coast. Assessment basins are chosen as study areas based upon the nature of the socio-economic and natural resource problems within them. The CDFW *Recovery Strategy for California Coho Salmon* (2004) and *Steelhead Restoration and Management Plan for California* (1996) are also useful in selecting basins. CWPAP has developed assessment methods, protocols and report outlines. The CWPAP has completed assessments of the Salt River (CDFW 2005), the Lower Eel River watershed (CDFW 2010), the Van Duzen River watershed (CDFW 2013), the South Fork Eel River watershed (CDFW 2014), and is working on an Outlet Creek watershed assessment as of 2015.

The assessment program's products are designed to meet these strategic goals:

- Organize and provide existing information and develop baseline data to help evaluate the effectiveness of various resource protection programs over time;
- Provide assessment information to help focus watershed improvement programs and to assist landowners, local watershed groups, and individuals in developing successful projects. This will help guide support programs, such as the CDFW Fishery Restoration Grants Program, toward those watersheds and project types that can efficiently and effectively improve freshwater habitat and lead to improved salmonid populations;
- Provide assessment information to help focus cooperative interagency, nonprofit, and private sector approaches to protect watersheds and streams through watershed stewardship, conservation easements, and other incentive programs;
- Provide assessment information to help landowners and agencies better implement laws that require specific assessments such as the State Forest Practice Act, Clean Water Act, and State Lake and Streambed Alteration Agreements.

Habitat trend monitoring is discussed in Chapter 8: Monitoring.

Beaver (*Castor canadensis*), and their landscape-altering activities are a unique aspect of salmonid habitat restoration. The SONCC coho salmon recovery plan identified beaver trapping as a major activity responsible for the decline of coho salmon (NMFS 2014). The activities of beaver have many benefits to salmonid habitats. The construction of beaver ponds historically contributed to increased channel complexity and floodplain connectivity. Juvenile coho salmon utilize beaver ponds as high quality off-channel rearing habitat in both summer and winter. Beaver ponds also store cool water for later-season release (Parker 1986), reduce downstream turbidity (Naiman et al. 1988), expand riparian forests (Pollock et al. 2007), and reduce erosive perturbation (Parker 1986). Studies by Pollock et al. (2007), DeVries (2012), and Andonaegui (2000) have shown that using beaver for habitat restoration is both effective and efficient. Beavers are largely absent from the Eel River, but have been recently sighted in Outlet Creek, Ten Mile Creek, and in the vicinity of Cape Horn Dam on the mainstem Eel River (Lanman et al. 2013, Riverbend Sciences 2014). Increasing channel complexity via increased beaver abundance is a recovery action identified by the SONCC coho salmon recovery plan (NMFS 2014).

Proposed Actions for Eel River Forum

1. The Eel River Forum will thoroughly review the State and Federal recovery plans and their analyses of stresses, threats, and priority recovery actions. The Eel River Forum will identify new habitat restoration and enhancement actions to be considered for adoption into the State and Federal recovery plans. The breadth of experience and knowledge from the group can be valuable to provide input to the agencies that will substantially expand on the priority actions needed for habitat restoration.
2. Identify changes to existing prioritization methods for habitat restoration and enhancement projects. For example, the recent South Fork Eel River CWAP discuses likely limiting factors but does not provide any clarity on order of importance or for what life-stages. Limiting habitat factors need to be explained with details on the mode of action and affected life stages within a population dynamics context.
3. Implement a habitat monitoring program, as discussed in Chapter 8: Monitoring.

6: THE EEL RIVER DELTA AND ESTUARY

Overview

Estuaries are highly productive ecosystems, providing habitat for a rich assemblage of aquatic and terrestrial species, and are a critical transition zone between riverine and marine environments. The Eel River delta and estuary (Figure 10), generally considered the area downstream of the Van Duzen River confluence, is the third largest estuary in California, covering approximately 33,000 acres (Table 4) (Salt River EIR 2011; CDFW 2010).

Figure 10. The mouth of the Eel River in 1951. (from Shuster aerial photograph collection).

A diverse fish and shellfish assemblage, including economically valuable species, such as salmonids and Dungeness crab, depend on the natural functions and habitat diversity of the estuary ecosystem (Table 5). Sensitive plant species identified in the Eel River Estuary include Humboldt Bay owl's clover, Point Reyes salty bird's beak, Western sand spurrey, Lyngbye's sedge, seacoast angelica, and dwarf alkali grass (Schlosser and Eicher 2012). The area supports year round bird use with 200 species of birds documented using the delta (Monroe et al. 1974). Furthermore, the area is an important stop-over point for migratory birds of the Pacific Flyway enroute from Patagonia to Alaska.

Table 4. Tidal marsh and estuary areas estimated by various sources.

Eel River Delta (up to the confluence with Van Duzen)	Area (acres)	Source
Total Eel River delta area	33,000	SR EIR
Tidal marsh (1854/55, 1890)	10,000	Roberts 1992, Laird et al. 2007
Tidal area (1870)	6,525	DFG –ERSSAP 97' pg 4
Tidal area (1970)	2,200	DFG –ERSSAP 97' pg 4
Tidal marsh (2007)	874	Laird et al. 2007
Tidal area (1989)	40% of original size	
Tidal prism reduction	60% reduction	

The importance of estuaries to numerous fish species is well established. Estuaries have high primary and secondary productivity and are widely considered important nursery habitat, contributing significantly to the early life history of many fish species, including salmonids (Simenstad et al. 2000, Beck et al. 2001). Healey (1982) proposed the concept of "estuarine dependence" in which tidal marshes and estuaries are considered a requisite rearing habitat for juvenile salmonids. Factors hypothesized to contribute to the importance of estuarine habitat for juvenile salmonids include: 1) higher growth rates resulting from abundant invertebrate food sources and favorable water temperatures, 2) predation avoidance, potentially resulting from higher turbidity of estuarine waters, and 3) a favorable transition area for the physiological adaptation from freshwater to seawater (smoltification).

Table 5. Fish and amphibian species inhabiting the lower Eel River and estuary [adapted from CDFW 2010].

Anadromous	
Coho Salmon	*Oncorhynchus kisutch*
Chinook Salmon	*Oncorhynchus tshawytscha*
Steelhead Trout	*Oncorhynchus mykiss C*
Coastal Cutthroat Trout	*Oncorhynchus clarkii*
Chum Salmon	*Oncorhynchus keta*
Eulachon	*Thaleichthys pacificus*
Pacific Lamprey	*Lampetra tridentata*
Green Sturgeon	*Acipenser medirostris*
White Sturgeon	*Acipenser transmontanus*
American Shad	*Alosa sapidissima*
Longfin Smelt	*Spirinchus thaleichthys*
Threespine Stickleback	*Gasterosteus aculeatus*
Coastrange Sculpin	*Cottus aleuticus*
Prickly Sculpin	*Cottus asper*
Freshwater	
California Roach*	*Hesperoleucas symmetricus*
Sacramento Sucker*	*Catostomus occidentalis*
Brown Bullhead*	*Ameiurus nebulosus*
Sacramento Pikeminnow*	*Ptychochelis grandis*
Green Sunfish*	*Lepomis cyanellus*
Marine or Estuarine Dependent	
Pacific Herring	*Clupea harengus pallasii*
Pacific Tomcod	*Microgadus proximus*
Topsmelt	*Atherinops affinis*
Bay Pipefish	*Sygnathus leptorhynchus*
Red-tail Surfperch	*Amphistichus rhodoterus*
Pile Surfperch	*Damalichthys vacca*
Walleye Surfperch	*Hyperprosopon argentum*
Shiner Surfperch	*Cymatogaster aggregata*
Pacific Sardine	*Sardinops sagax*
Northern Anchovy	*Engraulis mordax*
Surf smelt	*Hypomesus pretiosis*
Kelp greenling	*Hexagrammos decarammus*
Cabezon	*Scorpaenichthys marmoratus*
Pacific staghorn sculpin	*Leptocottus armatus*
Ringtail snailfish	*Liparis rutteri*
Jack mackeral	*Trachurus symmetricus*
Saddleback gunnel	*Pholis ornata*
Pacific sandlance	*Ammodytes hexapterus*
Tidewater goby	*Eucyclogobius newberryi*
Bay goby	*Lepidogobius lepidus*
Sand sole	*Psettichthys melanostictus*
English sole	*Parophrys vetulus*
Speckled sanddab	*Citharichthys stigmaeus*
Starry Flounder	*Platicthys stellatus*
Amphibians	
Pacific Giant Salamander	*Dicamptodon tenebrosus*
Northwestern Salamander	*Amybstoma gracile*
Rough-skinned newt	*Taricha granulosa*
Tailed Frog	*Ascaphus truei*
Pacific treefrog	*Hyla regilla*
Red-legged Frog	*Rana aurora*
Foothill Yellow-Legged Frog	*Rana boylei*
Bullfrog	*Rana catesbeiana*
Western Toad	*Bufo boreas*

The Eel River estuary is essential habitat for all juvenile salmonid species and has been designated critical habitat for salmon and steelhead under the Federal Endangered Species Act (ESA). The Eel River estuary is the southern extent of the known range of Coastal Cutthroat Trout, a little-studied species that is gaining attention through the efforts of the Coastal Cutthroat Trout Interagency Committee. The significance of estuary habitat for juvenile Chinook salmon is well documented (e.g., Reimers 1971; Healey 1982; Kjelson et al. 1982; Nicholas and Hankin 1988; Wallace and Allen 2012). Chinook often exhibit extended periods of residence in estuaries before migrating to the ocean. Working throughout coastal Oregon, Nicholas and Hankin (1988) found that juvenile Chinook salmon seldom returned as adults if they entered the ocean at less than 100 millimeters in length. Estuaries provide productive habitat where juvenile growth is often accelerated, particularly in the late-spring early-summer. Fish that are larger at ocean entrance often survive significantly better than smaller fish. Cannata and Hassler (1995) demonstrated that juvenile Chinook salmon increased in size in the Eel River estuary over spring and summer months (Figure 11).

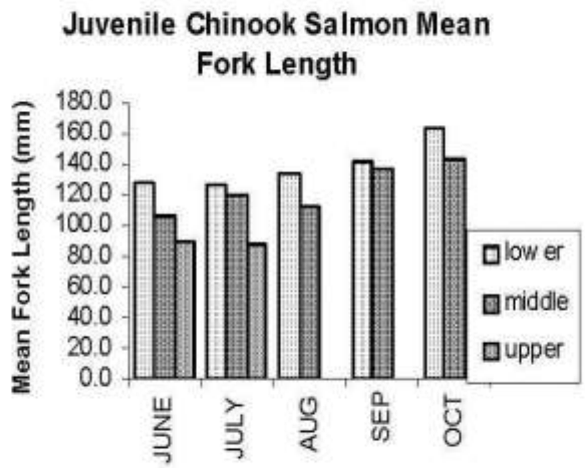

Figure 11. Mean fork lengths of juvenile Chinook salmon captured from lower, middle, and upper sampling sites in the Eel River estuary in 1994.

Traditionally, juvenile coho salmon were not thought to use estuaries other than to migrate through them on their way to the ocean. However, more recent work (e.g., Miller and Sadro 2003; Wallace and Allen 2007; Koski 2009; Roni et al. 2012; Antonetti et al. 2014; Bennett et al. 2014; Jones et al. 2014) has shown that throughout their range, juvenile coho salmon exhibit more diverse life history pathways than traditionally believed, including significant use of estuary habitat. For example, sampling salmonids in stream-estuary ecotones in Humboldt Bay, CDFW has identified at least three different types of juvenile coho salmon life history that use tidal zones (Mike Wallace, CDFW, Personal communication, 2013). The life histories identified are: (1) extended summer rearing of age-0 coho salmon in freshwater zones with suitable water temperatures, (2) extended winter rearing, potentially by an entirely different cohort of age-1 coho salmon, during which increased stream runoff expands the boundaries of the freshwater-dominated zone, and (3) brief rearing of spring age-1 in brackish zones for smolting.

Observing similar estuary life history pathways, other researchers (e.g., Bennett et al. 2014; Jones et al. 2014) have been able to show that juvenile coho salmon using estuaries survive to contribute to the returning spawner population. Intact functioning estuaries provide watersheds with additional habitat diversity, which promotes life history diversity, which can lead to greater resiliency and productivity of salmonid populations at the watershed and regional scales. Antonetti et al. (2014), working in the Klamath Basin, have shown that juvenile coho salmon from throughout the Klamath Basin, sometimes from more than 280km away (Shasta River), migrate downstream during the fall and winter to access low gradient wetland and stream habitat adjacent to the Klamath River estuary. These fish overwinter in this habitat before migrating to the ocean the following spring. Maintaining Klamath River estuary habitats and their connectivity to adjacent freshwater habitats is not only essential for local populations of coho salmon in the Lower Klamath Basin, but for coho salmon populations throughout the entire watershed.

Estuaries have also been shown to be important for juvenile steelhead. Using regression analysis of scale radius and fish length from adult steelhead returning to spawn in Freshwater Creek, Ricker (2003) estimated the length at which steelhead smolts entered the ocean. This analysis indicated the average size at ocean entry of returning adults was 194 mm, whereas the average smolt length at the Humboldt Fish Action Council Freshwater Creek trap was 156 mm. Ricker (2003) speculated that steelhead spend time growing in the estuary before entering the ocean. Bond (2006) showed that high growth rates of juvenile steelhead in an estuarine lagoon increased ocean survival of fish using the estuary for extended periods compared to fish that did not.

Given the presence of the Wiyot Tribe and the importance of the Eel River as a subsistence and cultural resource to the Tribe, restoration actions in the estuary and throughout the Eel River should be considered for multi-species benefits, ensuring that projects do not negatively impact other species (for example, fish passage projects that may create adequate passage for salmonids may not be sufficient for lamprey passage or meet the needs of tidewater goby). Ecosystem-focused restoration is preferred by many practitioners over a narrower focus on a specific species or life stage.

Historical Conditions

The Eel River delta and estuary historically provided a broad diversity of habitats, including a freshwater zone from the head of the delta (approximately at the Van Duzen River confluence) to the upper extent of tidal reach; a brackish ecotone composed of open water, an immense network of tidal channels and marsh surfaces; and a marine-dominated zone subject to daily tidal prism, wave energy, and ocean salinity. This report refers to this expansive delta-estuary ecotone simply as the ‘estuary’. The Salt River, a 47 mi^2 watershed draining the Wildcat Hills to the south, flows into the Eel River estuary just before the Pacific Ocean, and was historically a navigable slough channel. To the north of the Eel River mouth, McNulty Slough drains portions of the northern floodplain.

The indigenous Wiyot People derive their name from the Eel River, which in their language meant “plenty- from the immense quantities of salmon obtained by them every fall in that stream…” (Humboldt Times, September 23, 1854). Until being violently displaced by Euro-American settlers in the late 1800s, a large number of Wiyot villages thrived alongside the banks of the river.

From 1853 to 1922 the estuary supported a large commercial fishery that supplied fresh salmon and steelhead to markets in California, the east coast, and outside the country. Estimates of the annual catch approached 2 million pounds of salmon and nearly 500,000 pounds of steelhead (CDFW 2010). The estuary also provided a popular and productive sport fishery for salmon and steelhead (CDFW 2010) and was once considered one of the best angling streams for salmon and steelhead in the USA (Coupe and Taylor 2009).

Coastal cutthroat trout are the only non-stocked species that has been observed in any abundance in the Wildcat tributaries and the Salt River. Cutthroat trout were found to be abundant in streams tributary to the Salt River; specimens 76-203 mm in size were collected from Russ, Reas, Francis and Williams creeks (Dewitt 1954). In addition, the 1984 CDFW Coastal Cutthroat Inventory biologists noted that the variable physical appearance likely indicated an estuarine (tributary to estuary and back) or anadromous life history. The presence of coastal cutthroat trout in the lower Eel River system is supporting evidence that the steelhead and coho salmon would also be present as cutthroat trout are not known to be the only salmonid to occupy the an area.

Current Condition in the Estuary

The Eel River estuary has been significantly transformed over the last 150 years (CDFW 2010). The Josiah Gregg party arrived at the Eel River in late 1848-49. The Shaw brothers settled on land in Ferndale 1852 and soon afterward made the first land changes consisting of fern clearing for pasture and farm crop plots. Humboldt County records show that in 1855 the federal government allowed and encouraged wetlands and tide areas to be filled and fenced for property security. Levees and water diversions were built to improve agricultural uses of the land by reducing tidal incursion and buffering against large flood events. The network of levees and tide gates in the Eel River estuary has blocked the ebb and flow of tides and has reduced the volume of water (tidal prism) exchanged during tidal cycles. This wholesale land conversion transformed the estuary from a rich and diverse natural landscape to a highly managed, homogenous landscape composed primarily of agricultural lands. In 1870, the tidal area was estimated to be 6,525 acres (Table 4). By 1970, the estuary, inclusive of sloughs and side channels, was reduced to 2,200 acres, a 67% reduction (DFG –ERSSAP 97 pg 4). In 1989, the Soil Conservation Service estimated that the Eel River estuary was only 40 percent of its original size.

This wholesale land conversion corresponds to a general decline in the quality and quantity of the estuarine environment, a marked reduction in the tidal prism, and a decrease in inundated area. Urbanization in and around the towns of Ferndale and Fortuna has also led to a loss of estuarine habitat as well as a loss of agricultural lands.

Tidal prism is estimated to have been reduced by approximately 60 percent overall. This reduction, in combination with accelerated sediment delivery to the delta system from the watershed, altered sediment transport and storage processes in the estuary, which in turn has caused significant sediment aggradation, and a sharp reduction in channel capacity of the Eel River and adjacent, low-gradient tributaries. These changes have resulted in increased flooding of agricultural lands. In addition, there has been a dramatic loss of wetlands and habitat diversity (Downie and Lucey 2005).

A March 2013 presentation to the Eel River Forum by CDFW's David Kajtaniak of the Coastal Watershed Planning and Assessment Program (CWPAP) provided key findings and recommendations of the Lower Eel River Watershed Assessment, including: an overview of the Eel River estuary, historical conditions, fishing industry and beneficial uses, current fish distribution and habitat conditions. More detailed information describing the Eel River delta and estuary is available from the CDFW CWPAP's website (http://coastalwatersheds.ca.gov/) including the 2005 Salt River Watershed Assessment and the 2010 Lower Eel River Watershed Assessment. The Salt River Ecosystem Restoration Project EIR has detailed descriptions of the Salt River watershed and proposed restoration.

Degraded estuarine habitat conditions have contributed to the substantial population declines of all species of salmonids that historically used the Salt River basin and the Eel River. Yoshiyama and Moyle (2010) estimate that contemporary salmonid population abundance in the Eel River watershed is less than 5% of its historical abundance. The commercial fishery has been eliminated and the recreational fishery has been significantly reduced and is now catch and release only.

Agricultural Lands in the Delta-Estuary

The Eel River delta-estuary is also one of the largest and most important agricultural areas in Humboldt County, providing local communities and the County with tax revenues, jobs, a traditional rural lifestyle, and preservation of open space. Approximately 4,300 acres of this area is protected under the Williamson Act, and agricultural lands, in general, are protected by several County and State land-use policies and ordinances (Humboldt County General Plan of 1984; The Coastal Act of 1976). Despite these protections, recent trends in agricultural land conversion, primarily due to urbanization and land development and secondarily due to public acquisition have led to concern over loss of agricultural lands and the overall sustainability of agricultural activities.

The conversion of the Eel River estuary to agricultural lands carried out in the nineteenth century brought wealth and prosperity to the Eel River delta and estuary region. However, maintaining agricultural productivity in this dynamic landscape has required constant effort. These agricultural lands are subjected to immense tidal forces, large floods, and sedimentation rates that rank among the highest of any rivers in the world. In addition, the Eel delta is in close proximity to the Mendocino Triple Junction, and the entire estuary is prone to tectonic subsidence during inter-seismic periods, and large earthquakes in co-seismic periods. In the recent past, less regulatory scrutiny allowed agricultural operators to use mechanical equipment and other means to maintain productive pasture lands. However, in recent decades, water quality impairment, ESA listed species, and county land-use restrictions have rendered routine maintenance operations challenging and often infeasible. Working lands have slowly degraded and physical solutions are more elusive.

Restoring the Eel River Estuary

The Salt River Ecosystem Restoration Project, led by the Humboldt County Resources Conservation District (HCRCD), landowners, and a team of technical scientists, is a two-phased project that will attempt to reverse the environmental degradation in the Salt River and reduce impacts to agricultural lands. The project will restore the Salt River's capacity to drain low-lying agricultural lands during flood events by dredging 7 miles of the Salt River, create sediment basins to trap incoming fine sediment, and implement upland restoration actions to reduce sediment inputs from surrounding forested watersheds. The project also seeks to restore aquatic and wetlands habitats across the 7 river/riparian corridor miles and approximately 300 acres of tidal wetland. A forward-thinking group of stakeholders on the Salt River developed an adaptive management plan that will allow maintenance of this managed landscape by providing regulatory permit coverage for 10 years after the project construction is completed. Maintenance activities are triggered by thresholds in aggradation and sediment storage in the system.

Additional natural resource enhancement projects are underway in the lower estuary – at The Wildlands Conservancy's Eel River Estuary Preserve and at CDFW's Ocean Ranch. The Eel River Estuary Preserve (Preserve) occupies 1,255 acres of the Salt River basin and is located at the southwestern edge of the Eel River Delta, adjacent to the Pacific Ocean. Restoration on the Preserve will contribute to the restoration of coho and Chinook salmon through providing suitable salmonid rearing conditions in the estuary. The 900 acre CDFW Ocean Ranch Unit, with planning and design initiated in 2011, will restore additional estuarine wetlands. Together, nearly 3,000 acres of high-value tidal marsh, estuarine habitat, freshwater wetlands, and agricultural lands are slated for conservation and enhancement. In addition, the Wiyot Tribe currently plays an active role in restoring the health of the Eel River, by conducting monitoring and seeking opportunities to remove invasive species. The Wiyot Tribe relies on the Eel River as a subsistence fishery, and tribal members go "eeling" for lamprey, an anadromous fish, with traditional hooks in the estuary.

Figure 12. The Salt River Ecosystem Restoration Project.

These projects take a significant step toward restoring estuarine and seasonal freshwater habitat in the lower Eel River and promoting collaborative working relationships among the ranching and dairy community, resource managers, and conservation scientists. This has been achieved, in part, by developing projects that consider broader community needs, such as assisting agricultural operators overcome regulatory burdens to allow routine maintenance activities on their properties as well as addressing the need for drainage of agricultural lands to improve productivity.

Restoring the Eel River delta and estuary will provide significant benefits to salmonid populations. The Eel River has a highly simplified, highly modified estuary – if we take on the hard work of "complexifying" the estuary, salmonid populations will respond.

Sea level rise and its impacts to the Eel River estuary are an important consideration. Much work has been done to understand and anticipate impacts to nearby Humboldt Bay; however, this work has not yet been done for the Eel River, although there may be many similarities. Differences between the two estuary areas include size and complexity of estuarine channels, hardened areas (Humboldt Bay is bordered by several large communities with infrastructure that is fortified by riprap and other hardened structures and the Bay mouth is bordered by two jetties), and other impacts of human use, including dredging in Humboldt Bay which is not present in the Eel River estuary. It is therefore difficult to extrapolate Humboldt Bay modeling to other areas of the north coast, including the Eel River. However, sea level rise is crucial to consider when planning and implementing estuary restoration and enhancement projects or planning for the future of the Eel River estuary.

Brief Summary

In summary, impacts to the Eel River delta-estuary include:

- Reduction of tidal prism (sea-water volume)
- Loss of estuarine open water, slough channel, and tidal wetland and salt marsh habitat
- Loss of hydrologic connectivity (reduced and altered drainage patterns)
- Excessive sedimentation and channel aggradation

- Water quality impairment (eutrophication, temperature and dissolved oxygen impairment)
- Reduction of native fish species diversity (richness and abundance) and an increase in non-native fish species
- Loss of fish migratory access
- Loss of riparian habitat
- Shortage of large wood throughout the delta-estuary area
- Sea level rise

The cumulative effect of these watershed impacts, including: (1) a severely altered and degraded estuary, (2) increasingly burdensome constraints to agricultural operations that were routinely performed in the past, (3) severely depressed salmonid populations that rely on the estuary for rearing habitat, and (4) the threat of sea level rise, all point to the present need to pursue more unified and strategic solutions to restoration in the Eel River estuary.

Proposed Actions for Eel River Forum

1. Obtain bathymetric survey data and tidal stage data in the lower mainstem Eel River upstream to approximately the Van Duzen River, within the major lower river slough channels, and in tributaries. Data may be available from existing sources or may require new data collection effort. The bathymetric data will complement the coastal LiDAR data and should be merged to develop a Digital Elevation Model (DEM) of the Eel River delta and estuary. These data sets are needed for modeling sea level rise, for conducting flood assessments, and for natural resource enhancement planning.

2. Map all water management infrastructure throughout the Eel River delta and estuary, including tidegates, slough channel and tributary stream crossings (bridges and culverts), ditches and other man-made waterways, and dikes and levees.

3. Conduct a sea level rise (SLR) vulnerability assessment of the Eel River estuary to estimate changes to the lower Eel River's surface water levels and the shallow groundwater zone to anticipated increases in SLR. The SLR Assessment should include estimates of extreme water level return intervals, such as the 10-year or 100-year flood level, and tidal datums such as mean higher high water under different rates of SLR, as well as estimate the response of the shallow groundwater zone to incremental SLR. The resulting SLR Assessment should include inundation maps for areas vulnerable to sea level rise and increased groundwater levels in response to different rates of SLR.

4. Assess habitat and agricultural preservation goals for the Eel River delta and estuary, similar to the SF Bay Area Goals Project prepared by the San Francisco Estuary Institute (Goals Project 1999). This project would map current land uses, identify opportunities to preserve valuable prime agricultural lands, and identify opportunities and constraints to restoring natural resources and habitats where agricultural lands are of diminishing or marginal value. This information would provide input to an updated Local Coastal Plan as well as a sea level rise vulnerability assessment as discussed above. Using GIS, the coastal LiDAR topography, and tidal data (collected as described in task above), map the Eel River delta into hydrologically connected 'neighborhoods' (as was done in the Shasta River TMDL) to identify discrete zones within which manageable natural resource and agricultural enhancement projects can be proposed.

5. Promote habitat restoration throughout the delta and estuary: (1) Use levee setbacks or remove levees and modify or remove tidegates to increase tidal prism and restore connectivity of slough

channels with tidal marshes and floodplains; (2) Establish streamside protection zones to encourage growth of riparian vegetation to help stabilize stream banks; (3) Armor severely eroding banks with bioengineering techniques that secure large wood pieces into banks and integrate live trees into the stabilization project; (4) Where feasible, install livestock management fencing, acquire conservation easements, restore salt-tolerant vegetation species; (5) Address fish passage problems at tidegates and other water management structures; and (6) continue education and outreach, and fish monitoring.

6. Establish water quality monitoring stations along the Eel River mainstem, to collect tidal stage, salinity and temperature, nutrients and pH, and other parameters.

7. Provide incentives to private landowners to keep the streams that run through their property productive for fish. Many streams in the delta region flow through ranches. These ranches are commercial enterprises geared toward using the land to raise livestock. The condition of the streams in this region, with respect to fish habitat and water quality, has been diminished from this use of the land. Although the land is private, the fish are a public resource. Solutions must be targeted towards the wants and needs of the community.

8. Protect soil quality in the Eel River delta and estuary. Topsoil is the key to agricultural production on ranch lands. By retaining topsoil, landowners can maintain the productivity of their lands as well as improve the fishery productivity in the streams. Ranching, soil, and fish are interdependent.

9. Continue to promote/expand conservation easements and land acquisitions that would promote the removal or modification of tide gates and levees in order to restore tidal prism and tidal wetlands.

10. Manage water by protecting instream flows and manage sediment loading in the estuarine tributaries to support coastal cutthroat trout at a minimum where management for the 1+ coho salmon life history may be unattainable.

7: THE POTTER VALLEY PROJECT

Summary of the Issue

Since 1908, upper mainstem Eel River flows have been regulated, and water has been diverted to the Russian River Basin for hydroelectric power and agriculture via Pacific Gas and Electric Company's (PG&E) Potter Valley Project. The Potter Valley Project (Project) is a 9.2-megawatt storage and diversion project that functions as an inter-basin transfer system, diverting water from the upper Eel River into the East Branch Russian River across a natural divide (Figures 13 and 14). There are two major dams on the upper Eel River associated with the Project. Cape Horn Dam, which impounds Van Arsdale Reservoir, was constructed in 1908 to serve as the Project's diversion site. The current storage capacity of Van Arsdale Reservoir is approximately 194 ac-ft. Cape Horn Dam is equipped with a fish ladder, which was modified in 1987 to improve passage of Chinook salmon and steelhead. The original fish screen at the Project diversion was constructed in 1972, and an improved fish screen was completed in 1995. The diversion tunnel capacity is approximately 300 cfs, but is typically not operated at more than 250 cfs. Scott Dam, which impounds Lake Pillsbury, was constructed in 1921 to provide storage for the Project. The operational storage capacity of Lake Pillsbury has decreased over the years from approximately 94,000 ac-ft to 75,000 ac-ft. The reservoir is rapidly filling with sediment and by 2022 will be roughly 27 percent filled (NMFS 2002). Scott Dam has no fish passage facilities.

Figure 13. Map of Eel River and Russian River watersheds, showing location of the Potter Valley Project.

The drainage area above Scott Dam is approximately 288 mi^2, which is about 7.8 percent of the Eel River Basin. Approximately 92 percent of the drainage area above Scott Dam is in the Mendocino National Forest and Snow Mountain Wilderness. Highest elevations are nearly 7,000 feet, and approximately 38 square miles (13 percent) of land are over 5,000 feet in elevation. Above 5,000 feet, snowpack is usually dependable and can remain through May and into June many years. The headwaters of the Eel River receive an average of 70 inches of rain per year. According to the NMFS 2002 Biological Opinion, "VTN (1982) reported that prior to construction, 35 to 45 miles of spawning and rearing habitat existed above Scott Dam which supported 2,000 to 4,000 fall Chinook salmon and winter steelhead. However, recent studies by the Mendocino National Forest (USFS and USBLM 1995) estimate 100 to 150 miles of potential anadromous salmonid habitat have been blocked by the dam. Abundant residual steelhead (landlocked after the construction of Scott Dam) were documented in and above Lake Pillsbury by CDFG surveys (CDFG 1993 stream survey- unpublished data). Habitat to support winter and summer steelhead, spring and fall Chinook salmon, and possibly coho salmon is currently blocked."

The Project stores winter runoff in Lake Pillsbury, and then meters that water out through the year (particularly summer/fall) for power production and irrigation delivery in the Russian River watershed, and for fisheries protection in the Eel River. The original 50-year license for the Potter Valley Project was issued by the Federal Power Commission in 1922. The license was renewed in 1983 by the Federal

Energy Regulatory Commission (FERC) after a protracted relicensing process, and was then amended in 2004 (FERC 2004). The current PG&E FERC license expires on April 14, 2022. To initiate the relicensing process, PG&E will be required to file a Notice of Intent to File an Application for New License by April 14, 2017.

Figure 14. Schematic view of the PG&E Potter Valley Project looking southwest from the Mendocino National Forest headwaters.

The 2004 license amendment was partially based on NMFS Biological Opinion (NMFS 2002), which concluded that Project operations, as proposed, would have jeopardized the continued existence of listed anadromous salmonid species. NMFS then offered a 'Reasonable and Prudent Alternative' (RPA) and 'Reasonable and Prudent Measures' (RPM) intended to protect salmon and steelhead and avoid jeopardy. The RPA and the RPM, which were incorporated into the amended FERC license, include: a significantly modified streamflow regime below Cape Horn Dam to improve conditions for salmon and steelhead, the release of warmer surface water from Lake Pillsbury during the late winter/spring to promote timely downstream migration of juvenile salmon and steelhead, block water for release at the discretion of the resource agencies each year, an annual monitoring program for juvenile and adult salmonids and summer water temperatures, and Sacramento pikeminnow (*Ptychocheilus grandis*) suppression and monitoring.

The regulated flow regime required by NMFS' RPA for the Project requires flow releases that attempt to mimic the pattern and timing of the natural hydrograph of the upper Eel River watershed, to "provide Eel River salmonids with a quasi-natural hydrograph with sufficient flows for fall and winter migrations, spring emigrations, and in some years [to] provide improved summer rearing habitat in the mainstem Eel River below Cape Horn Dam" (NMFS 2002). Project flow regimes have attempted to mimic the pattern and timing of the natural hydrograph since 1979. The RPA flow regime reflects a modification of these earlier regimes based on the results of monitoring studies and water modeling efforts. Minimum flows are specified in the RPA for three different locations within the Project: Eel River below Scott Dam, Eel River below Cape Horn Dam, and East Branch Russian River below Potter Valley Powerhouse.

Minimum flow requirements in the Eel River below Scott Dam are specified in Section B of the RPA. These minimum flows range from 20 to 60 cfs between June 1 and November 30, and range from 20 to 100 cfs between December 1 and May 31 depending on water year classification. Bottom releases from Lake Pillsbury result in elevated flows and artificially cold water temperatures in the 12-mile long reach between the Project dams from late spring through fall, which help sustain high quality rearing habitat for juvenile Chinook salmon and steelhead. However, the cold water releases create an 'ecological trap' by discouraging juvenile outmigration in spring until the point at which downstream mainstem Eel River water temperatures may become inhospitable. PG&E, CDFW, and NMFS have experimented with 'block water' flow release strategies to encourage timely juvenile outmigration.

Minimum flow requirements in the Eel River below Cape Horn Dam are specified in Section A of the RPA. They are relatively simple in concept, although the actual mathematical computation is more complicated. The goal of the minimum flow requirements is to mimic the pattern and timing of the natural hydrograph. Flow releases during fall, winter, and spring are determined on a daily basis by measuring the daily inflow into Lake Pillsbury (in ac-ft), converting this daily volume into a 7-day running average flow rate (in cfs) to serve as an estimate of unimpaired flow, and then using this unimpaired flow estimate to compute an "index flow". The index flow is 70% of the unimpaired flow estimate, or "0.7 * Eel Unimpaired Flow". The RPA established lower and upper flow thresholds termed 'floor' and 'cap', which are applied to the index flow to determine the required minimum flow. Three rules are followed to compute the minimum flow requirement: (1) if the "index flow" is below the floor, the minimum flow requirement is equivalent to the floor; (2) if the index flow is between the floor and the cap, the minimum flow requirement is equivalent to the index flow; and (3) if the "index flow" is above the cap, the minimum flow requirement is equivalent to the cap. The resulting minimum flow requirements based on the floor and cap values also depend on antecedent conditions and the overall water year type; these flows are summarized in Section 5 (pg. 98-99) and in Table 8 (pg. 99) of the NMFS Biological Opinion, as follows:

- October 1 – November 30: From October 1 to October 15, the cap is linearly increasing from a value equal to the previous "summer flow" (defined below) on September 30 to 140 cfs on October 15. The floor is linearly increasing from a value equal to the previous "summer flow" on September 30 to the fall floor flow on October 15. The fall floor is equal to 25 cfs or the previous "summer flow" on September 30, whichever is greater. From October 16 to November 30, the cap is 140 cfs, and the floor is equal to the fall floor defined above.
- December 1 – March 30: The cap is 140 cfs. The floor is 100 cfs, except when the cumulative inflow into Lake Pillsbury is exceptionally low and the previous month's floor was not equal to 100 cfs, in which case the floor is 25 cfs.
- April 1 – May 15: The cap is 200 cfs. The floor is 100 cfs, except when the cumulative inflow into Lake Pillsbury is exceptionally low and the previous month's floor was not equal to 100 cfs, in which case the floor is 25 cfs.
- May 16 – July 30: the floor is exponentially decreasing from its value on May 15 to the "summer flow" on August 1. The cap remains constant at 200 cfs from May 16 through May 31 and then exponentially decreases from 200 cfs to the "summer flow" on August 1.
- August 1 – September 30: the cap and the floor are both equal to the "summer flow".

The "summer flow" is the minimum flow requirement established for the August-September period by the RPA and is dependent on current and previous water year classifications. The "summer flow" can range from 3 cfs during Very Dry water years to 35 cfs in successive Very Wet water years. "Summer flow" requirements were established to approximate unimpaired flows.

Actual Project flows are usually higher than the minimum required flows, for several reasons. PG&E releases flows higher than the required minimums (by ~5-10 cfs) as a buffer to reduce the risk of releases dipping below the minimum flow requirements, resulting in temporary non-compliance. Although accretion flows are relatively small during summer, they can provide substantial additional discharge to the river during the late fall, winter, and spring. Lastly, when Lake Pillsbury is full, the reservoir spills, and outflows from Lake Pillsbury mirror inflows.

Annual Hydrographs and Water Volumes

Since the 2004 license amendment, unimpaired inflows to Lake Pillsbury are estimated in order to compute flow releases below Cape Horn Dam. As a result, unimpaired daily average flow estimates are available for the Eel River at Cape Horn Dam for water years 2004 to the present. These annual hydrographs provide a baseline for comparing daily flow releases and for computing annual flow release and diversion volumes. Annual hydrographs of estimated unimpaired flows, regulated flow releases below Cape Horn Dam, and daily flow exports were plotted for each of the post-RPA water years. Example hydrographs for a Dry water year, 2008, and a Wet water year, 2011, are shown in Figures 15 and 16. Unimpaired, exported, and released annual volumes for water years 2004-2012 are presented in Table 6. It should be noted that a reinterpretation of the RPA rules governing diversions during spring has resulted in a reduction in diversions beginning with the 2007 water year. Thus, current Project operations are best reflected in Table 6 by water years 2007-2012.

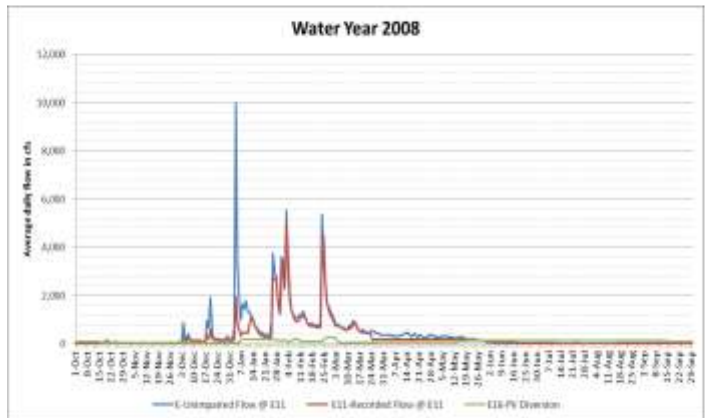

Figure 15. Annual hydrograph for the Eel River below Cape Horn Dam showing the estimated daily unimpaired flow, the actual flow, and the out-of-basin water transfer for a dry water year, 2008.

The historic average annual diversion based on PG&E data for the period 1923-72 was 155,000 ac-ft; elsewhere, the historic average has been reported as 160,000 ac-ft (FERC 2000). Since the 2007 reinterpretation of the RPA, the average annual diversion has dropped to 77,000 ac-ft. This water volume currently averages approximately 21.9% of the estimated unimpaired flow in the upper Eel River at the point of diversion (i.e., Cape Horn Dam), and 1.8% of the estimated unimpaired flow in the Eel River at Scotia.

Block Water

Block water for release at the discretion of CDFG to directly benefit salmon and steelhead was originally made available through the 1983 FERC Project license. Such releases were made on 17 occasions between 1985 and 1996. Eight of these release events were made in fall/early winter targeting upstream migration of Chinook salmon adults; eight were made in spring targeting downstream migration of juvenile Chinook salmon and steelhead; and a single release event was made in summer targeting maintenance of habitat for juvenile steelhead.

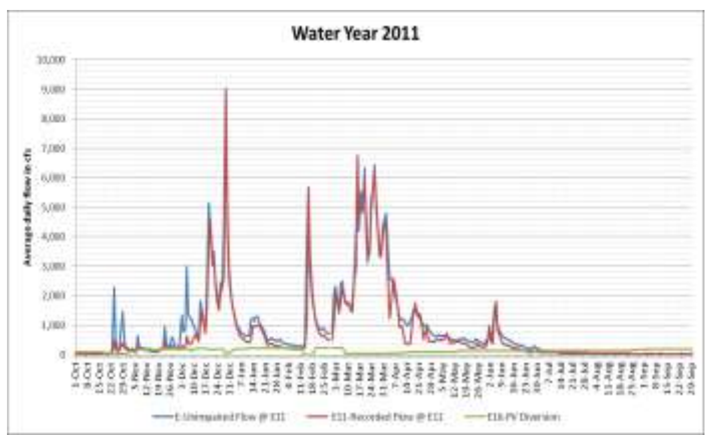

Figure 16. Annual hydrograph for the Eel River below Cape Horn Dam showing the estimated daily unimpaired flow, the actual flow, and the out-of-basin water transfer for a wet water year, 2011.

The RPA and license amendment extended the availability of block water and required PG&E to annually provide 2,500 acre-ft of water for release "at the discretion of resource agencies each water year" (NMFS 2002). In 2004, NMFS and CDFW developed block water release procedures to expedite responses and implementation of releases. As specified by these procedures, any stakeholder (including NMFS and CDFW) can contact either NMFS or CDFW to request the release of block water. Contact is to be made first by phone and then by email or fax with a written biological justification. NMFS and CDFW jointly make the final decision regarding block water releases and then contact PG&E to order such releases. In 2012, NMFS and CDFW developed block water guidelines intended to help determine when block water releases would benefit salmon and steelhead in the Eel River.

Table 6. Water volumes computed for the Potter Valley Project from available PG&E and published data from California Data Exchange Center (CDEC) for water years post-NMFS RPA flow

	Unimpaired Annual Inflow to Lake Pillsbury (ac-ft)	Regulated Annual Release below Van Arsdale (ac-ft)	Annual PVP Out-of-Basin Diversion (ac-ft)	Percent of Unimpaired Diversion
WY 2004	531,684	396,780	138,205	26%
WY 2005	498,514	354,909	128,506	26%
WY 2006	989,008	894,230	108,378	11%
WY 2007	215,873	144,623	83,350	39%
WY 2008	288,173	217,198	71,068	25%
WY 2009	199,123	129,452	60,024	30%
WY 2010	466,666	378,186	76,580	16%
WY 2011	643,169	545,609	100,776	16%
WY 2012	262,661	210,607	68,575	26%
Average	454,986	363,510	92,829	24%

The first "block water" release under the 2002 RPA occurred in May 2012. The flow release was developed to mimic a spring rain runoff event to encourage fish to emigrate, and enhance survival of downstream migrating juvenile Chinook salmon and steelhead from the 12-mile reach between Scott and Cape Horn dams. The release, comprised of warmer surface waters from Lake Pillsbury, was made during the period of May 18 to May 24, and coincided with the new moon on May 20 (Figure 17).

Conclusions based on this block water release were as follows (Butler 2012):

- Release encouraged Chinook salmon emigration, did not encourage movement of young-of-year steelhead
- Release encouraged adult lamprey to migrate upstream
- Data prompted improvements to fish ladder to increase ability of lamprey to successfully migrate through ladder

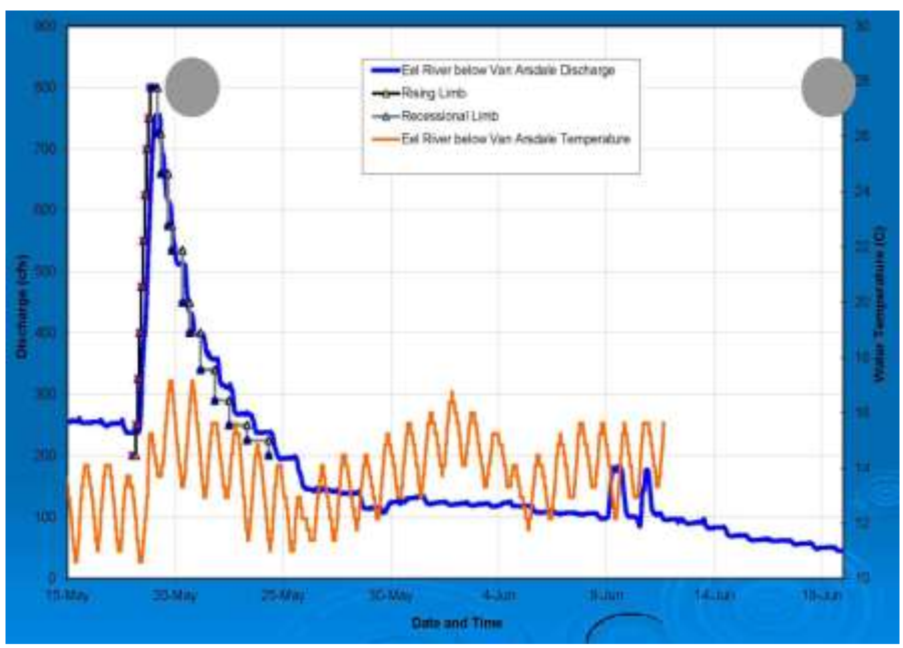

Figure 17. The WY2012 block water release hydrograph from the Potter Valley Project [from Butler 2012 Presentation to the Eel Russian River Commission].

- The block water release minimally impacted storage in Lake Pillsbury
- Release increased flows downstream of Van Arsdale potentially benefiting salmon and steelhead entering the Eel River from tributaries downstream of Cape Horn Dam (e.g., Chinook salmon and steelhead from Tomki Creek; Chinook salmon, coho salmon, and steelhead from Outlet Creek)

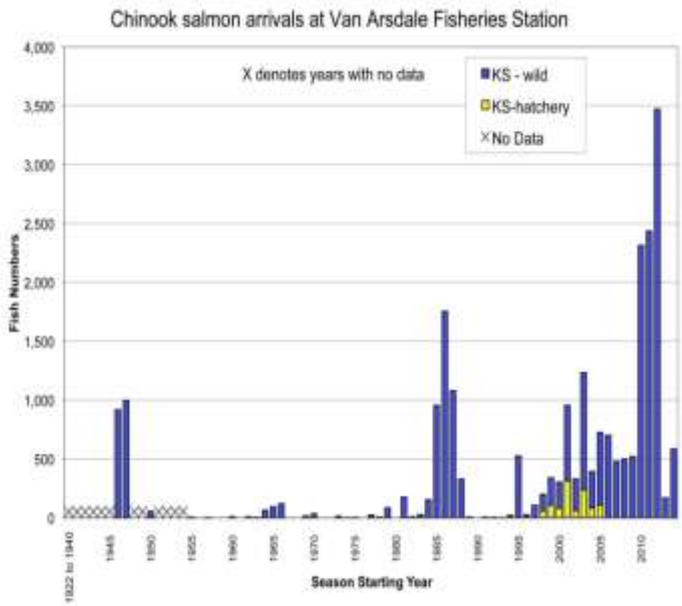

Figure 18. Adult Chinook salmon counts at Van Arsdale Fisheries Station on the Eel River at Cape Horn Dam for the period of record, 1922-2014

In the spring of 2013, NMFS and CDFW attempted an alternative spring flow release strategy. The 2,500 acre-ft of block water was not utilized due to low water availability, and instead PG&E made warm water surface releases from Lake Pillsbury through a radial gate at the top of Scott Dam, while minimizing bottom releases through the ‘needle valve’. However, the release strategy failed, as there was inadequate water storage in Lake Pillsbury to sustain the surface releases. Elevated water temperature targets intended to stimulate Chinook salmon to emigrate from the 12-mile reach below Scott Dam were not achieved.

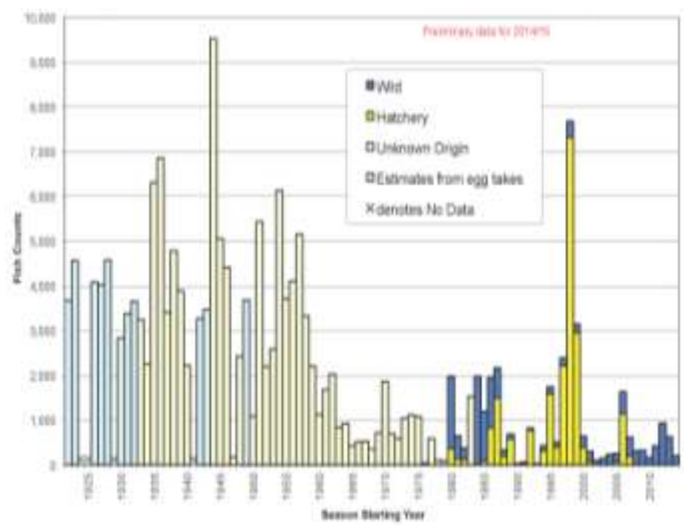

Figure 19. Adult steelhead counts at Van Arsdale Fisheries Station on the Eel River at Cape Horn Dam for the period of record, 1922-2014.

In the spring of 2014, NMFS and CDFW again requested the release of warmer surface waters from Lake Pillsbury to stimulate the timely downstream migration of juvenile Chinook salmon. From April 30 to May 29, PG&E incorporated surface releases into the total release at Scott Dam at varying percentages to achieve target temperatures of about 15°C. A significant increase in emigration of juvenile Chinook salmon and steelhead was achieved during these releases. Due to the continuing drought conditions in 2014, NMFS and CDFW requested use of the block water to improve habitat conditions for juvenile steelhead during the late summer and fall. PG&E increased releases at Cape Horn Dam from approximately 10 cfs to 20-28 cfs during the period of August 15 to October 10. These releases helped sustain cooler water temperatures and greater amounts of rearing habitat.

Status and Trends of Fishery Resources in the Upper Eel River

In association with the operation of the Potter Valley Project, there has been extensive monitoring of fishery resources and habitat conditions in the upper Eel River watershed from 1979 to the present time. Study efforts have included adult salmon and steelhead counts at Van Arsdale Fisheries Station (VAFS) at Cape Horn Dam, salmon carcass surveys, downstream migrant trapping, summer juvenile rearing monitoring, pikeminnow monitoring, water temperature monitoring, an instream flow study, and a critical riffle study. Study results are summarized in the following reports: VTN 1982; Beak 1986; SEC (Steiner Environmental Consulting) (SEC) 1987, 1988, 1989, 1990, 1991, 1992, 1993, 1994, 1995, 1996, and 1998; and PG&E 2006a-e, 2007a-e, 2008a-e, 2009a-e, 2010a-e,2011a-e, 2012a-e, 2013a-e, and 2014a-e.

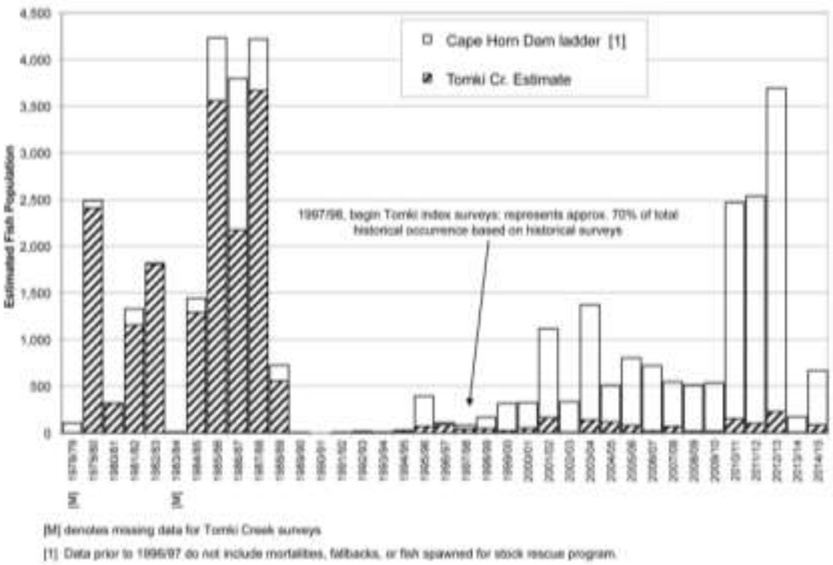

Figure20. Adult Chinook salmon returns to the upper Eel River watershed based on counts at the Van Arsdale Fisheries Station and carcass surveys in Tomki Creek for the period of record, 1978-2014.

Records of adult Chinook salmon and steelhead returning to VAFS have been kept since 1922 (Figures 18 and 19, respectively). To supplement these counts, salmon carcass surveys have been conducted in an index reach of the Eel River downstream of Tomki Creek (4 miles below Cape Horn Dam) and in several index reaches in the Tomki Creek watershed. The combined results of counts at VAFS and carcass surveys in Tomki Creek yield an index and distribution of historical fish returns to the upper Eel River watershed (Figure 20). Returns vary greatly over the years (Figures 18, 19, and 20) due to the effects of a variety of factors including: Project operations and flows, natural flow conditions, natural flood events, illegal water diversions, summer meteorological conditions, timber harvest, livestock grazing, agriculture (including marijuana cultivation), introduction of invasive species (e.g., Sacramento Pikeminnow), artificial propagation of salmon and steelhead, and ocean conditions

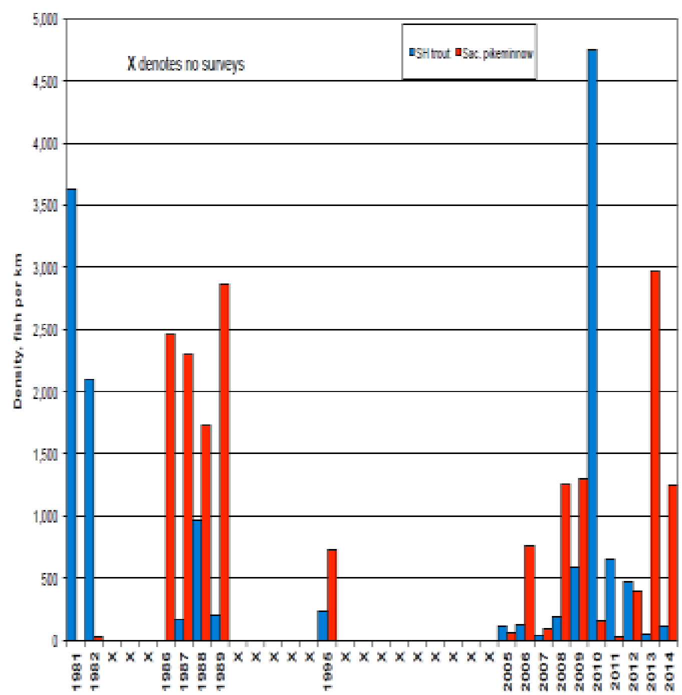

Figure 21. Juvenile steelhead and pikeminnow densities in fish/km during summer at an index site in the Eel River below Cape Horn Dam for the period of record, 1981-2014.

Summer fish rearing surveys conducted by backpack electrofishing in the Eel River between Cape Horn Dam and the Middle Fork Eel River provide an index of juvenile steelhead and pikeminnow populations from 1980 to the present. Lineal densities of steelhead and pikeminnow at two long-term monitoring sites, Eel River below Cape Horn Dam (a site with suitable temperature conditions for steelhead) and Eel River below Emandal (a site with unsuitable temperature conditions for steelhead), show the variation in steelhead and pikeminnow densities between years and between sites (Figures 21 and 22). Factors affecting the distribution and densities of steelhead include summer water temperature and the occurrence of pikeminnow. Temperatures increase in the Eel River in a downstream direction reaching limiting levels for steelhead through much of the reach between Cape Horn Dam and the Middle Fork (Figure 23).

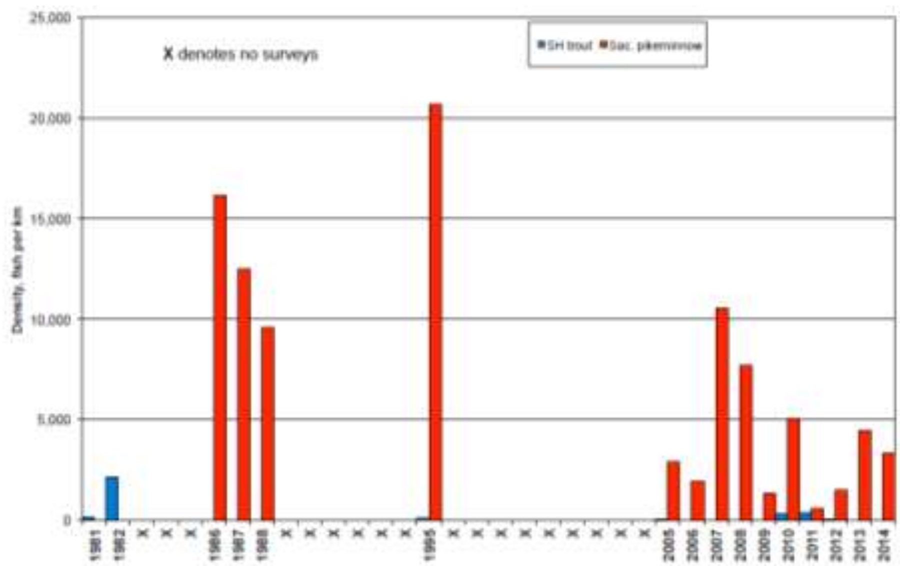

Figure 22. Juvenile steelhead and pikeminnow densities in fish/km during summer at an index site in the Eel River at Emandal for the period of record, 1981-2014.

According to the NMFS (2002) Biological Opinion, “Sacramento pikeminnow were introduced into the Eel River system around 1979. Since that time, this introduced predator has colonized much of the mainstem, and has infested the Van Duzen River and the South Fork Eel (Brown and Moyle 1991), both major tributaries. CDFG (1999 unpublished data) has conducted snorkel surveys of various reaches of the Eel River and South Fork, and reports a prevailing

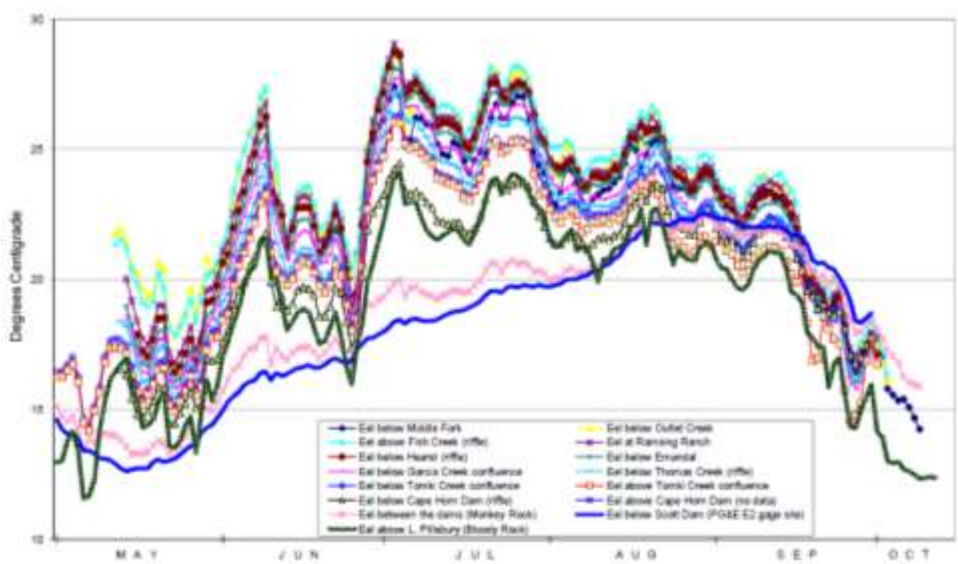

Figure 23. Daily mean water temperatures at selected sites in the Eel River from above Lake Pillsbury to the Middle Fork Eel River during the summer of 2013

trend that where large pikeminnow are found, steelhead are not found, and that the converse trend is also apparent. The implication is that Sacramento pikeminnow have displaced summer rearing steelhead, possibly aided by adverse habitat conditions for salmonids. Salmonids are known to be a component of the pikeminnow diet in the Eel River (Brown and Moyle 1997), and it is reasonable to assume that salmonids are preyed upon, and face competition from pikeminnow. In fact, it is widely held that pikeminnow constitute a major obstacle to the recovery of salmonids in the Eel River system."

Proposed Actions for Eel River Forum

The following actions associated with the operation of the Potter Valley Project were identified for consideration. It should be noted that most of these actions will likely be addressed during the upcoming FERC relicensing process, which is currently scheduled to be initiated in April 2017.

1. Evaluate the effectiveness of flow releases in the mainstem Eel River below the Potter Valley Project. Minimum flow releases were first increased in 1979 through a Project relicensing study agreement, and then further modified over the years based on the results of various studies. Currently, minimum flows are those required by NMFS' RPA. A comparison of the estimated unimpaired annual hydrographs with actual flows below Cape Horn Dam requires a detailed analysis to determine the effect of flow releases on Chinook salmon and steelhead spawning and rearing habitat, and water temperatures. There is a vast amount of data available for this type of analysis from monitoring studies conducted by PG&E and its contractors from 1979 to the present (VTN 1982; Beak 1986; SEC 1987, 1988, 1989, 1990, 1991, 1992, 1993, 1994, 1995, 1996, 1998; PG&E 2006a-e, 2007a-e, 2008a-e, 2009a-e, 2010a-e, 2011a-e, 2012a-e, 2013a-e, 2014a-e). One study of note for this analysis is the Instream Flow Study conducted by VTN (1982) to quantify the amount of potential habitat available for various life stages of Chinook salmon and steelhead as a function of streamflow. However, updated spawning and rearing habitat-flow relationships may be needed to improve the applicability of this study; this could involve the development of a new set of habitat suitability curves based on a review of existing curves or the collection of site-specific data. Regarding spring rearing and outmigration flow and temperature conditions, the NMFS Biological Opinion (NMFS 2002) states that the RPA flows would provide "improved conditions" for salmonids, but the Biological Opinion does not discuss how this was or could be quantified, and whether or not the improvements are enough to promote species recovery. Additionally, the NMFS Biological Opinion states (pg. 97) "After ten years of monitoring, the summer flow component of the RPA will be re-evaluated based on results provided in annual reports". An important task would be to determine if ongoing monitoring will provide an adequate basis for conducting this evaluation.

2. Prioritize the block water release schedule to consider spring releases first, then summer, fall, or winter releases as a secondary priority. NMFS and CDFW have management authority to determine block water release schedules, and have specified that using the block water during the spring outmigration period to stimulate juvenile Chinook salmon emigration from the 12-mile reach below Scott Dam is the highest priority use of block water. Currently, the block water allocation is reset on October 1 and is "saved" through the fall and winter to be used for those higher priority spring releases. However, if conditions do not warrant augmented spring releases, the opportunity to use the block water is compromised, making block water use in fall and winter unlikely. A solution would be to change the date when the water allocation is reset from October 1 to March 1 or April 1. This would allow PG&E and agency managers to observe the past winter's runoff year conditions (e.g., was it wet?, is the reservoir full?), and develop a preferred spring flow release hydrograph for the highest priority use of block water. Then, if block water is not used in spring, the 2,500 acre-ft could be used to supplement summer flow releases for improved steelhead rearing or released in late fall or winter for improved

upstream migration of adult Chinook salmon. In this manner, better decisions could be made to benefit critical life stages of Chinook salmon and steelhead throughout the year. In addition, agency managers should develop a broad set of objectives and continue to experiment with flow release approaches for different water year conditions. These objectives can be developed with a broader stakeholder group to allow more innovative input on block water release objectives.

3. Re-evaluate pikeminnow abundance monitoring and suppression efforts associated with the Project. The NMFS RPA requires that PG&E implement a pikeminnow abundance monitoring and population suppression program in the Project area. PG&E established three monitoring sites in the Eel River between Scott and Cape Horn dams, and has been employing raft electrofishing techniques annually from 2006 to 2014 (with the exception of 2011 due to safety issues associated with marijuana grow activities) to monitor pikeminnow abundance. Additionally, PG&E monitors pikeminnow abundance annually at seven backpack electrofishing sites and nine snorkeling sites between Cape Horn Dam and the Middle Fork Eel River as part of a summer rearing monitoring program. Based on the results of these monitoring efforts, it has been speculated that pikeminnow abundance may have stabilized and/or declined over the years; however, the results are not conclusive. In 2006, PG&E began implementing pikeminnow suppression efforts using gill nets, but this approach resulted in “take” of juvenile steelhead, so the effort was halted. No other acceptable technique has been identified through consultation with NMFS and CDFW; thus, no subsequent suppression efforts have been attempted by PG&E. In light of the non-conclusive monitoring results and the lack of an acceptable suppression technique, the pikeminnow abundance monitoring and suppression efforts should be re-evaluated. Consideration should be given to re-scoping the monitoring program, possibly using direct observation techniques to target development of an abundance estimate or index of abundance in the Eel River reaches between Scott and Cape Horn dams, and between Cape Horn Dam and Outlet Creek. Tracking annual abundance could provide important information on population fluctuations potentially related to Project flow releases. Additionally, a thorough review of pikeminnow suppression techniques and their efficacy in the upper Eel River watershed should be conducted.

4. Re-evaluate the salmonid habitat capacity of the Eel River watershed above Scott Dam. Estimates of the extent of salmonid habitat and numbers of returning fish in this area differ significantly in past efforts. The VTN (1982) “Mitigation Study” estimated historical spawning densities at 70 Chinook salmon/mile and 94 steelhead/mile and current potential spawning densities at 35 Chinook salmon/mile and 42 steelhead/mile, based on adult salmon and steelhead returns in the Eel River below Cape Horn Dam and in Tomki Creek. Habitat area estimates in the upper watershed were based on limited aerial reconnaissance surveys conducted by PG&E and VTN, which estimated 35.7 miles of spawning and rearing habitat above Scott Dam. Combining the spawning densities with habitat area estimates above Lake Pillsbury and areas inundated by Lake Pillsbury provided estimates of historical production of 2,499 Chinook salmon and 3,356 steelhead and current potential production of 1,250 Chinook salmon and 1,499 steelhead. NMFS’ Biological Opinion (NMFS 2002) referenced the VTN study and suggested estimates of 2,000 to 4,000 fall Chinook salmon and winter steelhead. NMFS (2002) also referenced studies by the Mendocino National Forest (USFS and USBLM 1995), which estimated “100 to 150 miles of potential anadromous salmonid habitat blocked by the dam”. The Mendocino National Forest document (pg. 19) stated “About 100 miles of anadromous fish habitat were made inaccessible to returning salmon and steelhead.” Given the disparity and uncertainty in these estimates, an updated and refined evaluation of habitat available above Lake Pillsbury is warranted. Methods used should be compatible with estimates from other areas of the Eel River Basin, and ideally across basins, to place habitat amounts in context.

5. Evaluate the water dynamics of Lake Pillsbury to learn more about the characteristics of the source water for downstream releases, particularly temperature and dissolved oxygen. Lake Pillsbury is the storage reservoir for the Project and serves as the primary water source for the Eel River downstream of Scott Dam, particularly during the dry summer and fall months when natural accretion flows are at reduced levels. Thus, the quality of the water in the upper Eel River is highly dependent on the characteristics of the water released from Lake Pillsbury. Water can be released from Lake Pillsbury by two means: 1) through the needle valve at the base of Scott Dam, which takes water from the bottom of the reservoir; and 2) through a series of radial gates and slide gates along the top of Scott Dam, which takes water from the surface of the reservoir when storage is high enough to reach the spillway level of the dam. Typically, the storage level reaches the spillway sometime during the winter/spring runoff period and remains high enough to allow surface releases for varying periods of time during winter/spring, depending on the water year type. The gates along the top of the dam are required to remain in the open position during the winter/spring period until April 1, per requirement of the State Division of Safety of Dams. After April 1, in years of sufficient storage, surface releases can be managed by means of the gates. During the late spring, summer, and early fall, the reservoir stratifies, forming a cold water pool at its lower levels with reduced dissolved oxygen levels. Releases from this cold water pool through the needle valve at Scott Dam produces artificially low water temperatures in the Eel River downstream. These cold water releases provide excellent nursery habitat for juvenile steelhead between Scott and Cape Horn dams during summer, but can also delay the emigration of juvenile Chinook salmon and steelhead until downstream conditions become inhospitable. To help better manage the source water in Lake Pillsbury and make appropriate releases for the protection of Chinook salmon and steelhead in the Eel River downstream, existing water temperature and water quality data from Lake Pillsbury and the upper Eel River should be evaluated, and the collection of additional data and modeling should be considered.

6. Evaluate the potential of using PG&E watershed lands along the Eel River between Scott and Cape Horn dams for creating a salmon/steelhead interpretive park and for implementing habitat restoration in tributary streams. The Stewardship Council, a private non-profit foundation, was formed as part of a PG&E Settlement Agreement with the California Public Utilities Commission to oversee the conservation of 140,000 acres of PG&E watershed lands in perpetuity. Over 7,000 acres of watershed lands are included in the Eel River Planning Unit of the Stewardship Council's Land Conservation Program, much of which is located along the Eel River between Scott and Cape Horn dams. The Stewardship Council is currently in the process of donating some of these lands to the Potter Valley Tribe and the U.S. Forest Service. However, the bulk of these lands will be retained by PG&E subject to conservation easements. The Stewardship Council also has $15 million that will be used to fund enhancement projects on the 140,000 acres of PG&E watershed lands. Funding for enhancement projects can be received through the Stewardship Council's grant application process. Creation of a salmon/steelhead interpretive park and implementation of habitat restoration are activities that could qualify under this enhancement program. An interpretive park could include the development of streamside trails and signage regarding salmon, steelhead, and other aquatic resources in the watershed. Restoration activities could include the implementation of improved fish passage at road crossings of tributary streams and erosion control measures to reduce stream sedimentation. The potential for pursuing such activities along the Eel River between the two dams under the Stewardship Council's enhancement program should be evaluated.

7. Review the vast amount of fisheries, hydrology, and water temperature information that is available for the Project area to gain a more thorough understanding of the status of fish populations in the upper Eel River watershed and the effects of Project operations. Over 30 years of fisheries monitoring has

been conducted since a major change was made to the Project flow regime in 1979 to mimic the pattern and timing of the natural hydrograph, and 10 years of monitoring has been conducted under the current RPA flow regime that was implemented in 2004. A variety of analyses of the monitoring data have been conducted, particularly in relation to the previous relicensing effort that resulted in the amended license issued in 2004. Additionally, numerous recommendations regarding Project operations, particularly the flow regime, were made by various parties during the previous relicensing effort, and continue to be made post-relicensing. Finally, additional data beyond that which has already been identified could likely be found through an extended literature search. PG&E, state and federal resource agencies, and other stakeholders should embark on an effort to assemble and review all pertinent available data.

8. In preparation for the upcoming FERC relicensing process for the Project, begin a collaborative effort to discuss and consider potential changes in Project operations and other protection, mitigation, and enhancement (PM&E) measures for anadromous salmonid populations in the upper Eel River. The current Project license expires on April 14, 2022; the relicensing process will officially begin by April 14, 2017 when PG&E is required to file a Notice of Intent to File an Application for New License (NOI). FERC's Integrated Licensing Process for project relicensing involves implementation of a series of formal steps that provide for collaboration amongst the project owner/applicant, resource agencies, tribes, non-governmental organizations, other stakeholders, and FERC. The primary steps in the relicensing process include:

- Applicant files a NOI and a Pre-Application Document. The Pre-Application Document includes available information about the project and its effect on resources, a well-defined plan for developing the license application, and a list of preliminary studies and issues.
- FERC conducts public scoping, which includes preparation of a scoping document, scoping meetings, a site visit, and preparation of a revised scoping document based on public and agency input.
- Applicant prepares study plans to address information needs and resource issues. The steps involved in this process include stakeholders' submittal of study requests, applicant's preparation and filing of proposed study plans, meetings to discuss proposed study plans and resolve study disagreements, applicant's filing of revised study plans, and FERC's issuance of a Study Plan Determination.
- Applicant conducts studies and prepares license application. The steps involved in this process include applicant's performance of the studies, applicant's preparation and filing of study reports with FERC and stakeholders for comment, meetings to discuss study results, applicant's preparation and filing of draft license application with FERC and stakeholders for comment, and applicant's preparation and filing of final license application with FERC along with copies to the stakeholders.
- FERC processes license application. The steps involved in this process include FERC's review of the application, FERC's notification of application being ready for environmental analysis and solicitation of interventions and comments, FERC's issuance of its environmental analysis pursuant to the National Environmental Policy Act, and FERC's issuance of its decision on the application.

In the years leading up to the formal relicensing process, PG&E, state and federal resource agencies, and other stakeholders should engage in discussions focused on relicensing issues that could contribute to recovery efforts for anadromous salmonids in the watershed. Such discussions, based on the collaborative review of pertinent available information discussed in Item 7, would better inform decision making during relicensing by helping to identify potential changes to Project operations or implementation of additional PM&E measures for the benefit of anadromous salmonids in the Eel River, while balancing beneficial water uses in both the Eel River and Russian River watersheds.

Actions Identified but Not Agreed Upon by Members of the Eel River Forum

One additional action was identified for potential inclusion during the development of this chapter: consideration of the Conservation Recommendations made as part of NMFS' Biological Opinion for Project operations (NMFS 2002), including Project decommissioning. However, agreement could not be reached amongst the parties of the Eel River Forum for the acceptance of this action.

The identified action is as follows:

Consider the Conservation Recommendations of NMFS' Biological Opinion for Project operations (NMFS 2002). PG&E, state, and federal resource agencies, as well as other stakeholders, should engage in a process to discuss and consider NMFS's Conservation Recommendations:

> CR1. "FERC should require PG&E to use its resources to widely disseminate information relating to Sacramento pikeminnow suppression efforts that might rely on public participation for implementation.";
>
> CR2. "FERC should require PG&E to fund annual salmon carcass surveys in index sections of the Eel River, Tomki Creek, Outlet Creek and any other stream reach deemed significant by fishery biologists.";
>
> CR3. "FERC should require PG&E to install gages above Lake Pillsbury and on Tomki Creek as described in the original DOI/NMFS proposal…". Data from these gages "could provide a more direct measure of the unimpaired flows targeted for release by the flow schedule, provide a better means to index pulse flow timing, and build a form of redundancy into the unimpaired flow estimation procedure…";
>
> CR4. "FERC should study the feasibility and develop a schedule for decommissioning and removing the Potter Valley Project in order to restore unimpaired flows and restore access to historical salmonid spawning and rearing habitats to aid in the recovery of listed salmonids in the Eel Basin."

Notes of interest for each of these action items include:

> CR1. Suppression activities for Sacramento pikeminnow are currently on hold, pending identification of suppression methods that are not harmful to juvenile steelhead.
>
> CR2. Salmon carcass surveys are being conducted annually in index reaches of the Eel River and Tomki Creek, under a requirement of the FERC license.
>
> CR3. Currently, daily unimpaired flows at the Project are being calculated through a mass balance equation using changes in Lake Pillsbury storage levels and flows measured at downstream Project gages (E-11, Eel River below Cape Horn Dam; and E-16, total diversion flow through Potter Valley Powerhouse). A gage site on Tomki Creek near its mouth was maintained

from 1985 to 1995 as part of a Project-related fisheries monitoring study. Mean daily discharge data are reported for this period by SEC (1998).

CR4. Project decommissioning is likely to be raised during the upcoming Project relicensing process.

The primary argument in favor of accepting this action was that all actions that may contribute to the recovery of anadromous salmonids in the watershed should be considered, even those that may be addressed during the upcoming FERC relicensing process. Arguments in opposition to accepting this action included: this set of actions, particularly Project decommissioning, is not within the purview of the Eel River Forum and will be addressed during the FERC relicensing process; and parties dependent on water deliveries to the Russian River for various beneficial uses could not agree to considering cessation of these diversions.

8: MONITORING

Summary of the Issue[5]

The objective of this chapter is to describe ongoing monitoring activities in the Eel River and to summarize the status of fish populations. An inventory of current monitoring activities is necessary to provide a framework for organizing and expanding future monitoring efforts. This chapter considers three types of monitoring: biological monitoring, habitat monitoring and citizen-based monitoring.

Eel River stakeholders need information with which to track progress of efforts to recover threatened biological resources. Monitoring provides essential information to inform decisions and actions. We have more detailed information today on Eel River aquatic resources than we did 50 years ago, yet the status and trajectory of the Eel River's resources remain unclear. Advances in monitoring methods and technologies have the potential to provide abundant data; so planning and integration of monitoring efforts is critical.

Biological monitoring is focused on anadromous fishes of the Eel River (lamprey, sturgeon, salmonids), with California Department of Fish and Wildlife (CDFW) undertaking most Endangered Species Act (ESA) monitoring, and the Wiyot Tribe leading lamprey and sturgeon monitoring efforts. Some habitat monitoring overlaps with water quality monitoring, including flow (see Chapter 2: Water Resources), temperature, and sediment. The State Water Board and Regional Water Board oversee water quality monitoring. Citizen-based monitoring can measure both physical and biological aspects of the Eel River, and primarily includes organized volunteer or non-agency efforts. Citizen groups include: Eel River Recovery Project (ERRP), the Wiyot Tribe, Friends of the Eel River, and Friends of the Van Duzen River. Citizen monitoring can provide highly useful data, as well as provide opportunities to connect the community to the Eel River's abundant natural resources.

Several organizations currently conduct biological monitoring in the Eel River basin. Pacific Gas & Electric carries out spawner surveys in Tomki Creek and the Upper Eel River above Van Arsdale. Most of this PG&E monitoring is in the immediate vicinity of Scott and Cape Horn dams. For adult salmonids, CDFW conducts coho salmon spawner surveys on the Van Duzen, South Fork, and upper Mainstem Eel rivers (and in Lawrence, Grizzly, Bull, Hollow Tree, Sproul, and Outlet creeks) and summer steelhead surveys in the Middle Fork Eel and Van Duzen rivers. CDFW also monitors resident trout within Mendocino National Forest, and maintains juvenile salmonid index reaches in Hollow Tree, Ryan, and Willits creeks. A cooperative effort between CDFW, Humboldt Redwood Company (HRC), and Pacific States Marine Fisheries Commission (PSMFC) monitors juvenile salmonid distribution on the lower Eel and Van Duzen rivers with summer snorkel surveys. The Eel River Recovery Project (ERRP) and the Wiyot Tribe lead efforts for fall Chinook salmon dive counts, with participation from HRC.

Some non-salmonid fish monitoring is also underway in the Eel River watershed. Pacific lamprey passage is recorded at the CDFW Van Arsdale Fisheries Station, and Sacramento pikeminnow have been monitored by PG&E. Green Sturgeon populations in the Mainstem and Middle Fork Eel rivers are under investigation by the Wiyot Tribe. Diversity of estuarine fishes is measured monthly at Salt River restoration sites by the Humboldt County Resource Conservation District (HCRCD).

For the sake of organization, physical habitat monitoring will be considered separate from biological monitoring, though the linkage is of utmost importance. Habitat monitoring is necessary to determine if restoration actions are effective and if positive responses are quantifiable. Some water quality parameters, such as temperature and turbidity, are also important biological habitat variables.

[5] The Eel River Recovery Project provided much useful information on planned monitoring activities for use in the Eel River Action Plan. These contributions are summarized here, while more detail is presented in Appendix A.

Water quality monitoring is conducted by PG&E (temperature), the Regional Water Quality Control Board Surface Water Ambient Monitoring Program (SWAMP: metals, nutrients, algae, invertebrates), the Wiyot Tribe's "first flush" parameters (phosphorus, nitrogen, total/fecal coliform, total petroleum hydrocarbons, priority metals, suspended solids, and semi-volatile organic compounds), HCRCD, HRC (temperature, turbidity), CDFW (temperature), California State Parks (temperature), and ERRP (temperature, toxic algae). Temperature impairment and blue-green algae issues are discussed further in Chapter 3: Water Quality. Implementation of water quality measures for temperature and sediment TMDLs is the responsibility of the Regional Water Board. These ongoing monitoring activities are summarized in Table 7.

Table 7. Current monitoring activities in Eel River sub-basins, as of May 2015. Lead agency, type of monitoring, and location of monitoring is presented.

Target	Van Duzen/Lower Eel (below SF)	South Fork	Mainstem Eel (SF to MF)	Middle Fork	Middle Mainstem (MF to Tomki Creek)	Upper Mainstem (above Tomki Creek)
Coho Adult	ERRP, Wiyot, HRC Adult snorkel surveys: pools below South Fork confluence	CDFW spawning surveys: GRTS sample, CDFW Sproul Creek LCM(proposed)		N/A	CDFW Van Arsdale Fishery Station	N/A
Coho Juvenile	CDFW, HRC , PSMFC juvenile snorkel surveys: GRTS sample	CDFW Sproul Creek LCM(proposed)		N/A	CDFW Outlet Creek Index	N/A
Chinook Adult	ERRP, Wiyot, HRC Adult snorkel surveys: pools below South Fork confluence	CDFW spawning surveys: GRTS sample, ERRP snorkel surveys, CDFW Sproul Creek LCM(proposed)		CDFW spawning surveys: Hollow Tree Creek	PG&E spawning surveys: Tomki Creek, Eel Mainstem CDFW Van Arsdale Fishery Station	CDFW spawning surveys: Hollow Tree Creek
Chinook Juvenile	CDFW, HRC, PSMFC juvenile snorkel surveys: GRTS sample	CDFW Sproul Creek LCM(proposed)			CDFW Van Arsdale Fishery Station	CDFW juvenile salmonid index reaches: Hollow Tree, Ryan, Willits creeks
Steelhead Adult	CDFW summer steelhead snorkel surveys	CDFW spawning surveys: GRTS sample, CDFW Sproul Creek LCM(proposed)		CDFW summer steelhead snorkel surveys	PG&E spawning surveys: Tomki Creek, Eel Mainstem CDFW Van Arsdale Fishery Station	CDFW spawning surveys: Hollow Tree Creek
Steelhead Juvenile	CDFW, HRC, PSMFC juvenile snorkel surveys: GRTS sample	CDFW Sproul Creek LCM(proposed)			PG&E summer fish rearing monitoring: between Cape Horn and MF, CDFW Van Arsdale Fishery Station	CDFW juvenile salmonid index reaches: Hollow Tree, Ryan, Willits creeks
Lamprey, Sturgeon, Trout, etc.	Wiyot Tribe lamprey plan Wiyot Tribe vegetation/ avian species richness: Cock Robin Island, HCRCD: Salt River fish diversity	ERRP observations of Sacramento pikeminnow, beavers	Wiyot Tribe: Mobile Sturgeon Surveys		CDFW Van Arsdale Fishery Station: lamprey, PG+E: Sacramento pikeminnow monitoring	Mendocino National Forest resident trout surveys: 125 streams
Sediment	HRC turbidity: Bear and Jordan creeks	ERRP observations of sediment deposits				

Temperature	Wiyot, ERRP, SWAMP, HRC	SWAMP, ERRP, Cal. State Parks	SWAMP	SWAMP	CDFW, PG&E, SWAMP	
Water Quality	Wiyot first flush parameters (2), SWAMP long term (4), HCRCD Salt River (12)	SWAMP long term (4), SWAMP beach bacteria (8)	SWAMP	SWAMP long term: MF at Dos Rios	SWAMP	
Algae, nutrients	ERRP toxic algae	ERRP toxic algae, SWAMP nutrient biostimulation sites (6)				
Other Habitat	HRC: LWD, pools, substrate, canopy (22 reaches); SWAMP PSA: macroinverts and habitat (2 in Lawrence Creek)	SWAMP PSA macroinverts and habitat (1)	SWAMP PSA macroinverts and habitat at Panther Creek above Welch Creek			

List of abbreviations for Table 7. CDFW: California Department of Fish and Wildlife, ERRP: Eel River Recovery Project, GRTS: Generalized Random Tessellation Stratified, HCRCD: Humboldt County Resource Conservation District, HRC: Humboldt Redwood Company, LCM: Life Cycle Monitoring, LWD: Large Woody Debris, PG&E: Pacific Gas and Electric, PSA: Perennial Streams Assessment, PSMFC: Pacific States Marine Fisheries Commission; SWAMP: Surface Water Ambient Monitoring Program.

Status of Fishes in the Eel River

As with most major California rivers, native fish of the Eel River have been locally extirpated or are in decline, while exotic species have become established. For example, steelhead were historically present in 463 Eel River streams, but are currently present in only 332 of these streams (Becker and Reining 2009). Likewise, coho salmon are absent in many historically occupied tributaries of the lower Eel and Van Duzen rivers (NMFS 2014), and have recently become restricted to cooler west-side tributaries of the South Fork Eel River (CDFW 2015).

The diversity of fish species, along with amphibians, invertebrates, mammals, and birds, is an indicator of ecosystem health. Therefore, all of these organisms are important, though funding sources to-date have focused on salmonids due to their "threatened" ESA listing status. Common fishes of the Eel River are presented in Table 8, while fish and amphibians of the Eel River estuary are listed in Table 5 of Chapter 6: The Eel River Delta and Estuary.

Pacific lamprey were once prevalent enough to (mistakenly) give the "Eel" River its name. Lamprey, and Green Sturgeon were considered for ESA listing in 2003 and 2004, respectively, due to population declines in the southern portion of their ranges (Klamath-Siskiyou Wildlands Center 2003, NMFS 2005). NMFS determined ESA listing for these species was not warranted, but classified them as Species of Concern. Green sturgeon populations are found in the Middle Fork Eel River, and other independent populations may exist in other Eel River sub-basins (NMFS 2005). Although there is limited data on the historical distribution and abundance (Klamath-Siskiyou Wildlands Center 2003), the current known distribution of Pacific lamprey in the Eel River has been compiled from anecdotal evidence by Stillwater Sciences (2010).

Although it is clear that Eel River salmonid populations have seen an enormous historical decline, the extent of recovery of Eel River salmonid populations remains difficult to ascertain from existing data (Good et al. 2005, Williams et al. 2011). Fish were counted at the Benbow Dam on the South Fork Eel River from 1938 to 1975. These counts documented a decline of coho salmon, and other species (Table 3). Adult Chinook salmon and steelhead have been counted annually at the Van Arsdale Fish Station (VAFS) since 1933, creating the longest duration adult survey data set in the Eel River Basin (see Figures 2, 3 in Chapter 1: Introduction for illustration of decline). The reasons for this decline are only summarized in this document, and are analyzed in detail within state and federal recovery plans.

The Eel River has three federally listed species of anadromous salmonids: coho salmon, Chinook salmon, and steelhead. The Southern Oregon/Northern California Coasts (SONCC) coho salmon Evolutionarily Significant Unit (ESU), California Coast (CC) Chinook salmon ESU, and Northern California Steelhead Distinct Population Segment (DPS) are federally listed as threatened (United States Office of the Federal Register 1997, 1999, 2000). Coastal cutthroat trout also inhabit the lower Eel River, representing the southern extent of that species' range, but are currently not listed. Eel River resident rainbow trout are also found above the extent of anadromy, and could contribute to the genetic diversity of downstream anadromous steelhead (Wilzbach et al. 2012).

Table 8. Fish fauna of the Eel River.

Species	Status	Life history	Notes
Native species			
Pacific lamprey, *Entosphenus tridentatus*	D	Anad	Namesake of Eel River
River lamprey, *Lampetra ayresi*	R	Anad	
Pacific brook lamprey, *L. richardsoni*	R	Res	
Green sturgeon, *Acipenser medirostris*	R	Anad	Few recent records
Sacramento sucker, *Catostomus occidentalis*	C	Res	
Eulachon, *Thaleichthys pacificus*	R	Anad	Probably extinct from Eel River
Southern Oregon Northern California coho salmon, *Oncorhynchus kisutch*	T	Anad	Distinct Population Segment (DPS)
California coast Chinook salmon, *O. tshawytscha*	T	Anad	Evolutionarily Significant Unit
Pink salmon, *O. gorbuscha*	R	Anad	Probably extinct from Eel River
Chum salmon, *O. keta*	R	Anad	
Resident rainbow trout, *O. mykiss*	C?	Res	Interbreeds with steelhead
North California coast winter steelhead, *O. mykiss*	T	Anad	DPS
North California coast summer steelhead, *O. mykiss*	T	Anad	DPS
Coastal cutthroat trout, *O. clarki clarki*	D	Anad	
Prickly sculpin, *Cottus asper*	C	Res	Young can rear in estuary
Coast range sculpin, *C. aleuticus*	C	Res	Young rear in estuary
Threespine stickleback, *Gasterosteus aculeatus*	C	Anad/Res	
Introduced (alien) species			
American shad, *Alosa sapidissima*	D	Anad	
Threadfin shad, *Dorosoma cepedianum*	A	Res	Pillsbury Reservoir
Golden shiner, *Notemigonus chrysoleucus*	C	Res	Pillsbury Reservoir
California roach, *Lavinia symmetricus*	A	Res	
Sacramento pikeminnow, *Ptychocheilus grandis*	A	Res	
Speckled dace, *Rhinichthys osculus*	C	Res	Van Duzen River
Brown bullhead, *Ameiurus nebulosis*	C	Res	Pillsbury Reservoir
Green sunfish, *Lepomis cyanellus*	C	Res	
Bluegill, *L. macrochirus*	A	Res	Pillsbury Reservoir
Largemouth bass, *Micropterus salmoides*	A	Res	Pillsbury Reservoir

Abbreviations for status are: A = abundant, C = common, D = declining, R =rare, T = listed as a threatened species under the ESA. From Yoshiyama and Moyle 2010.

Threats to Eel River Fishes

NMFS recommends monitoring the following threats to salmonid persistence: 1) loss of habitat, 2) hydropower operations, 3) harvest and overutilization, 4) hatcheries, 5) disease and predation, 6) inadequate regulations, and 7) natural causes (Crawford and Rumsey 2011). Some of these threats directly affect salmon populations (i.e. harvest), while other threats act primarily on the quality and availability of salmonid habitat. All of these threats (except harvest) affect the broader biological community of the Eel River, and not just salmonids.

Loss of habitat is the primary concern for many native Eel River fish (see Chapter 5: Habitat Restoration). Habitat monitoring is discussed later in this chapter. Hydropower operations limiting anadromous habitat at the PG&E Potter Valley Project are licensed by the Federal Energy Regulatory Commission, and are discussed in detail in Chapter 7: Potter Valley Project.

Harvest threats cannot currently be directly determined for Eel River Chinook salmon due to a lack of data (O'Farrell et al. 2012). Instead, the harvest rate for Klamath Mountain Chinook salmon is limited in order to protect CC Chinook salmon stocks (PFMC 2014). The offshore area surrounding the Eel River mouth is closed to fishing, though in-river portions of the Eel basin are open to catch-and-release fishing for Chinook salmon and steelhead.

- Recommendation: investigate the effect of mixed-stock ocean fishery on Eel River Chinook salmon populations using methods outlined by O'Farrell et al. (2012).

At present, there are no hatcheries in the Eel River basin, though local Chinook salmon genetic diversity may have been affected by hatchery outplants as recent as 1993 (Bjorkstedt et al. 2005) and steelhead were planted in the South Fork Eel River as recently as 1995 (PG&E 1998). Hatchery influences are not likely to be a conservation risk to Eel River Chinook salmon (Good et al. 2005). Disease problems for Eel River salmonids are currently not a threat, although increased stresses due to continual habitat degradation (especially temperature) may increase disease risks in the future (NMFS 2007). Predation on juvenile salmonids by invasive Sacramento pikeminnow is a threat (NMFS 2007).

Inadequate regulatory mechanisms pose a threat to salmonids that can only be controlled by human intervention. Despite numerous overlapping agency efforts to protect valuable salmonid resources, many threats and stresses that affect salmonid survival are avoidable and continue un-checked. For example, marijuana cultivation sites are known to illegally divert water and deliver sediment to streams from illegal road building (Bauer et al. 2015). The Regional Water Board has begun a program to inspect larger cultivation sites and correct harmful activities. Illegal grading, poorly constructed roads and forest clearings can all be identified from aerial imagery. A water-storage program similar to the one in the Mattole watershed could reduce illegal water diversions from the fully appropriated Eel River (see Chapter 2: Water Resources).

Global climate change operates at a slow pace relative to human alterations of the landscape. Increased water temperatures (Isaak et al. 2012), lower summer flows (Barr et al. 2010), more intense storms (Bates et al. 2008) and the resulting higher winter flows (Doppelt et al. 2008) are some scenarios likely to result from global climate change. Salmonids evolved in dynamic environments, and climate change will test the limits of adaptations to these more extreme conditions. Shorter-term climatic changes to the California Current (and the ocean food chain) are linked to the Pacific Decadal Oscillation (Jacobsen et al. 2012). Changes to the ocean food supply in turn affect anadromous Eel River fishes.

No assessment of Eel River steelhead and Chinook salmon population status relative to recovery targets is currently available (with limited data for coho salmon). NMFS released the public review draft of the Multi-Species Recovery Plan in 2015, which describes Eel River Chinook salmon and steelhead population targets. Recent salmonid monitoring activity in the Eel River has focused on coho salmon, in part because only the SONCC coho salmon recovery plan is complete and because coho salmon are listed under the California Endangered Species Act (CESA). NMFS anticipates that many current coho salmon recovery objectives and actions will overlap with the needs of other salmonid species.

Coho salmon

Coho salmon were the first salmonid listed as threatened in the Eel River basin (1997), and are the most threatened extant species in the basin (Yoshiyama and Moyle 2010). An extended freshwater rearing period makes the species especially susceptible to poor habitat conditions during over-summer low flow periods. The NMFS recovery goal for a low threat of extinction is 28,700 adult spawners in the entire Eel River system. Yoshiyama and Moyle (2010) gave a historical estimate of about 100,000 adult coho salmon for the basin. The recovery target for coho salmon is thus lower than historical abundance, but should ensure long-term survival of the species (NMFS 2014). Basin-wide CDFW coho salmon spawner surveys of the South Fork Eel River began in 2010. CDFW estimated that there were 1,023 coho salmon redds in 2010-2011, and 1,084 coho salmon redds in 2011-2012 for the South Fork Eel River watershed, which is equivalent to over 2,000 spawners (CDFW 2015).

NMFS identified seven coho salmon populations in the Eel River basin. One population occupies a coastal sub-basin: 1) The Lower Eel/Van Duzen rivers, while the other six are found in interior sub-basins: 2) the South Fork Eel River, 3) the Mainstem Eel River, 4) the North Fork Eel River, 5) the Middle Fork Eel River, 6) the Middle Mainstem Eel River, and 7) the Upper Mainstem Eel River (Williams et al. 2006). NMFS (2014) set recovery targets for these populations based on a model of the potential of stream reaches to support rearing coho salmon, rather than historical data.

The North Fork and Middle Fork coho salmon populations in this basin are assumed extirpated (CDFG 2004, Yoshiyama and Moyle 2010) and the Upper Mainstem population contains critically low numbers of coho salmon (Jahn 2010). Depensation occurs when a low number of spawners leads to reduced production or survival of eggs, because of reduced success in finding mates or a high egg predation rate (NMFS 2014). If a population is below the depensation threshold, depensation is occurring and the population is at high risk of extinction. Of the six coho salmon populations in the Eel River basin, all but one (the South Fork Eel River) is at high risk of extinction. The North Fork Eel, Middle Fork Eel, and Upper Mainstem Eel rivers populations are at high risk of extinction if not locally extinct. Given the low amount of accessible coho salmon habitat in these populations, NMFS expects them to serve a supporting role in recovery. NMFS will use sufficient juvenile occupancy as a measure of recovery of these populations. NMFS will use spawner targets associated with a low risk of extinction as the measure of recovery of coho salmon populations in the South Fork Eel River (9,600 spawners), Lower Eel/Van Duzen River (7,900 spawners), Middle Mainstem Eel River (6,400 spawners), and Mainstem Eel River (4,800 spawners).

Chinook salmon

The Eel River once supported a Chinook salmon fishery (Lufkin 1996) and the largest population of Chinook salmon in the ESU range (Yoshiyama and Moyle 2010). These fall spawners generally spawn in larger mainstem reaches than tributary spawning coho salmon and steelhead trout. The spring-run life history of Chinook salmon is assumed extirpated from the basin (Bjorkstedt et al. 2005). A shortage of data currently limits the potential for Eel River Chinook salmon recovery (NMFS 2007). ERRP dive counts of fall Chinook have documented increased numbers in recent years (ERRP 2015, see Chapter 1: Introduction). NMFS set recovery targets for Chinook salmon populations in the lower mainstem/South Fork Eel rivers (7,300 spawners), Van Duzen River/Larabee Creek (2,900 spawners), and the upper Eel

River (10,400 spawners). The most impaired life stage for Eel River Chinook salmon is the pre-smolt (NMFS 2015).

Steelhead

Two distinct runs of steelhead exist in the Eel River: the more abundant winter run, and the less abundant summer run. While there is relatively limited data on winter run abundance (Good et al. 2005), they are likely less imperiled than coho salmon and Chinook salmon (Yoshiyama and Moyle 2010). Summer steelhead are known to persist in areas of the Middle Fork Eel and Van Duzen rivers, but are assumed extirpated from the South Fork Eel River (CDFG 1992). NMFS has recovery targets for many sub-populations of winter-run Eel River steelhead. Among the larger populations are the South Fork Eel River (19,000 spawners, plus 500 summer-run), Middle Fork Eel River (9,400 spawners), North Fork Eel River (6,300 spawners), Van Duzen River (6,200 spawners), the upper mainstem Eel River (4,200 spawners), Outlet Creek (3,800 spawners) and Tomki Creek (2,700 spawners). Summer rearing juveniles are the most impaired life stage of Eel River steelhead (NMFS 2015). The CDFW Steelhead Report and Restoration Card Program obtains some angler data for the recreational steelhead fishery on the Eel River.

Biological Monitoring

Ongoing lamprey research by the Wiyot Tribe and Stillwater Sciences is focused on population assessment, with lamprey spawning and distribution surveys conducted in Wiyot Ancestral waters (Stillwater Sciences 2014). In addition to lamprey monitoring, these groups have used mobile DIDSON (sonar camera) surveys of 192 river kilometers for sturgeon population assessment (Josh Strange, Stillwater Sciences, pers. comm.). Both white and green sturgeon were sighted in the Eel River estuary during snorkel surveys for fall Chinook salmon (ERRP 2015). The Wiyot Tribe has expressed interest in operating a system to detect sturgeon entering the Eel River which were tagged elsewhere.

- Recommendation: Install a sonic receiver detection array at sites within the Eel River sturgeon migration corridor, including marine, estuarine, and riverine areas.

Sacramento pikeminnow were accidentally introduced to the Eel River via Lake Pillsbury, where they were likely used as fishing bait. Sacramento pikeminnow are known to prey on and compete with juvenile salmonids (Nakamoto and Harvey 2003). The Eel River's altered (warmer) temperature regimes favor Sacramento pikeminnow over salmonids (Reese and Harvey 2002). Sacramento pikeminnow eradication is very unlikely in the Eel River. Instead, efforts focus on Sacramento pikeminnow suppression and control (see Chapter 9: Potter Valley Project). The following recommendation is discussed in Chapter 9:

- Recommendation: In lieu of annual Sacramento pikeminnow suppression action, PG&E should re-scope and implement a Sacramento pikeminnow abundance monitoring plan using direct observation techniques, targeting an abundance estimate or index of abundance in the Eel River reach between Scott Dam and Cape Horn Dam, and in the reach between Cape Horn Dam and Outlet Creek. Tracking annual abundance will provide important information on population fluctuations potentially related to PVP flow releases.

The Humboldt County Resource Conservation District oversees restoration work on the Salt River (see Chapter 6: The Eel River Delta and Estuary), and evaluates response to habitat improvements. Twelve sites around restored areas are visited monthly. Water quality and fish samples are gathered at each site. The monthly visits monitor the diversity of fishes inhabiting the sites over time (Darren Ward, HSU Fisheries, pers. comm.).

Salmonid Monitoring

Three types of ESA monitoring pertain to ESA salmonid listing: 1) status and trend monitoring, 2) implementation and compliance monitoring, and 3) effectiveness monitoring (Crawford and Rumsey 2011). NMFS recommends that salmonid status and trend monitoring be focused on four Viable Salmonid Population (VSP) criteria: 1) abundance, 2) productivity, 3) connectivity, and 4) diversity (McElheny et al. 2008). In addition to gathering information on the status of salmonid populations, threats to salmonid habitat and persistence also need to be monitored (Crawford and Rumsey 2011).

CDFW and NMFS developed a *Coastal salmonid Monitoring Plan* (CMP, Adams et al. 2011). The CMP proposes monitoring focused on two essential elements: 1) the status and trends of salmonid population, ranges, distribution attributes, and habitat conditions, and 2) the performance of salmonid recovery efforts. CDFW is implementing several salmonid monitoring tasks in the Eel River basin, in accordance with the CMP and federal recovery plans. The *Recovery Strategy for California Coho Salmon* (CDFG 2004) outlines steps needed to remove coho salmon from California's own ESA list. Specific population monitoring actions are described for individual watersheds in the SONCC coho salmon recovery plan (NMFS 2014).

To aid resource agencies and the public in evaluating ESA-listed salmonids, NMFS issued the document: *Guidance for Monitoring Recovery of Pacific Northwest Salmon and Steelhead* (Crawford and Rumsey 2011). Specific protocols for salmonid population monitoring are described by the CMP (Adams et al. 2011) and by the American Fisheries Society Publication: *Salmonid field protocols handbook: Techniques for assessing status and trends in salmon and trout populations* (Johnson et al. 2007). NMFS recovery documents specific to Eel River populations should dictate which monitoring activities are done.

- Recommendation: Integrate or modify existing data collection protocols to fit into larger recovery plans (CMP, Eel River Action Plan, SONCC coho salmon recovery plan).

Adult Salmonid Abundance

Adult coho salmon abundance in California is currently determined by survey estimates of redd abundance (Adams et al. 2011). A Generalized Random Tessellation Stratified (GRTS) sample of survey reaches is used to expand to the landscape scale. CDFW has conducted coho salmon spawner surveys throughout the South Fork Eel River since 2010. Spawner surveys in the upper Eel River, Outlet Creek, and Tomki Creek near the Cape Horn Dam currently give an index of adult abundance in the Upper and Middle Fork Eel River sub-basins. Monitoring adult salmonids at more locations in the Eel River would aid in assessing the status of those populations.

Adult counting stations are not feasible for larger Eel River reaches, since they generally require large infrastructure (i.e. dams). A sonar camera (DIDSON/ARIS) may be a viable alternative to obtain accurate counts for larger geographic areas of the Eel River basin. Identification of different species from DIDSON images has been identified as a research need by the SONCC coho recovery plan (NMFS 2014), and NMFS does not currently support sonar population estimates where salmonid runs overlap. CDFW has already employed sonar technology on North Coast rivers, including the Mad River, Redwood Creek, and the Smith River (Phil Bairrington, CDFW, pers. comm.).

- Recommendation: Establish a sonar counting station (either DIDSON or ARIS) at the mouth of the South Fork Eel River and/or on the lower mainstem Eel River, to supplement and validate current CMP adult abundance estimates based on redd surveys.

- Recommendation: Investigate and demonstrate ability to differentiate species using sonar technology for times when runs overlap.

Annual snorkel counts of adult fall Chinook salmon are organized by the Eel River Recovery Project and undertaken by volunteers, the Wiyot Tribe, and HRC. The surveys cover over 30 miles of river, including deep holding pools found below the South Fork Eel River confluence and in spawning reaches further upstream (e.g., Bear Creek, Sproul Creek). Coho salmon and steelhead are occasionally sighted during these surveys. The direct observation and video documentation of Chinook salmon could provide an important indicator of run timing and index of abundance if they were consistent with established protocols and sufficiently quantify the error associated with estimates. These counts provide valuable reach-specific information, adult distribution data, and can aid in management of PVP releases to help upstream migration. Snorkel surveys are also used by CDFW in the Middle Fork Eel River to monitor adult summer steelhead. These annual surveys have been ongoing since 1996.

- Recommendation Identify and employ approved adult snorkel survey protocols, including error estimation. Investigate if and how adult snorkel surveys can be used to assess adult distribution under CMP. Investigate if snorkel survey observations of species run-timing may aid in differentiation of sonar images.

Juvenile Salmonid Abundance, Survival Rates

Juvenile salmonids are more sensitive to freshwater conditions than adult spawners are because they spend more time in the environment, often in summer when conditions are the worst. Smolt abundance is used to estimate survival rates because it reflects freshwater habitat conditions. Knowledge of the differing survival of salmonids in freshwater and marine environments can identify what is limiting the production of a population (Adams et al. 2011).

A life cycle monitoring station (LCM) is a place where smolt and adult abundance are monitored. LCMs can be used to: (1) estimate abundance of adult coho salmon and downstream migrating juveniles; (2) estimate marine and freshwater survival rates; and (3) track abundance of juveniles coincident with habitat modifications. LCMs should be located and designed for complete counts of smolts and adults using weirs, fences, traps, live mark/recapture techniques, sonar, or other techniques (Adams et al. 2011). Adult counts may be used to calibrate spawning ground surveys used to estimate live adult abundance, redd abundance, and carcass abundance.

The CMP proposes use of LCMs to determine freshwater survival rates at a sub-watershed or basin scale (Adams et al. 2011). The location and seasonal timing of existing LCM stations are based on coho salmon distribution. In the SONCC coho domain, monitoring in the *interior* Eel River is planned to occur at the proposed Sproul Creek coho salmon LCM in the South Fork Eel River. Inferences from the South Fork Eel River LCM about ocean survival would apply to other interior Eel River sub-basins. Freshwater survival rates and derived population growth rates from the South Fork Eel River may not be applicable to the other Eel River sub-basins.

The southern *coastal* basins of the SONCC domain are represented by the ongoing Freshwater Creek (Humboldt Bay) coho salmon LCM. Coho salmon survival rates in the lower Eel/Van Duzen River population are expected to be similar to those at the Humboldt Bay tributaries LCM on Freshwater Creek. An LCM for Eel River Chinook salmon and/or steelhead would aid in assessing those populations.

Salmonid Distribution, Diversity

Distribution of adult salmonids in the Eel River can be determined from spawner surveys and summer steelhead dives, while distribution of juvenile coho salmon is currently assessed using summer snorkel surveys. Coho salmon juvenile occupancy surveys should be carried out in all independent populations without an LCM, specifically the Mainstem and Middle Mainstem Eel rivers (NMFS 2014). Extension of these surveys to a broader geographic scope is limited by land access in much of the watershed.

Genetic diversity is assessed using analysis of DNA obtained from tissue samples. Life history diversity is assessed by monitoring run timing, age class structure, and life history strategies. CDFW is currently investigating the feasibility of collecting Chinook salmon carcass genetic samples for Genetic Stock Identification. Anglers and other river-using citizens have recently been employed to gather more samples (Seth Ricker, CDFW, pers. comm.). Many other monitoring tasks exist on the road to recovery, including research into new monitoring methods.

- Recommendation: Expand snorkel surveys for juvenile coho salmon occupancy to all accessible reaches of the Eel River.
- Recommendation: Develop a procedure for collecting and archiving tissue samples for future assessment to track changes in genetic diversity and identify stocks.

Habitat Monitoring

The quantity and quality of aquatic habitats in the Eel River affect fish populations, as well as people inhabiting the watershed. Monitoring the response and effectiveness of habitat restoration has been lacking to date (see Chapter 5: Habitat Restoration). The status and trends of Eel River aquatic habitats must be known to determine effectiveness of restoration and de-list threatened species.

Some habitat issues facing the Eel River include: lack of complexity, high temperatures, altered hydrology, and reduced pool depths. A lack of off-channel and floodplain habitats may limit overwinter survival for salmonids, with no refuge areas for fish during high flows. Sediment inputs and water diversions have reduced pool depth and frequency, making survival during summer months difficult for species reliant upon cool water. The history of logging in the watershed has reduced the volume of in stream large wood, while some habitat is unavailable due to a lack of connectivity.

Sediment and temperature were among the first habitat problems to be identified for the Eel River. Between 1999 and 2007, the USEPA developed TMDLs for temperature and sediment impaired sub-basins of the Eel River. Since these issues have not been resolved, habitat monitoring should include these, and other key limiting factors identified by state and federal recovery plans.

Recent habitat monitoring in the Eel River watershed includes an inventory of habitats lost due to North Coast Railroad passage barriers (CalTrout in 2012). A Passage Assessment Database (PAD), which includes the Eel River, was published by CalFish (Becker and Reining 2009). Habitat monitoring is part of HRC's Timber Harvest and Aquatic Habitat Conservation Plans. Pool dimensions, cover rating and area, and LWD counts are noted during CDFW summer snorkel surveys for coho salmon spatial distribution monitoring (Garwood and Ricker 2015). Habitat changes due to expanding rural development have not been assessed, but this geospatial data either exists or can be easily gathered.

Habitat monitoring is often done on a small geographic scale for specific remediation efforts (e.g. Salt River estuary restoration, see *Biological Monitoring*). A coordinated effort to monitor habitats on a larger, basin-wide scale has not been attempted (nor funded) for the Eel River. The North Coast Watershed Assessment Program (NCWAP) has identified many of the elements needed to track Eel River habitat conditions (NCWAP 2014). The Columbia Habitat Monitoring Program (CHaMP) protocol is currently being applied on Pudding and Caspar creeks along the Mendocino coast, and could be expanded in the Eel River basin. The protocol focuses on measuring important salmonid habitat variables, including physical aspects of the water column, pool depth, riparian cover, flow, and macroinvertebrates (CHaMP 2014).

Physical habitat measurements, including V-star (measure of pool volume), pool frequency, and McNeils metrics have been recommended for Eel River SONCC coho salmon recovery planning by Kier Associates and NMFS (2008). The NCWAP lower Eel River assessment discusses riparian canopy density, salmonid spawning substrate, shelter/cover, and percent fine sediment (NCWAP 2014). Repeated measurements of these types of habitat variables taken from a GRTS sample would provide habitat trend data to inform salmonid recovery (CHaMP 2014, NMFS 2014). The SONCC coho salmon recovery plan recommends an initial survey of coho salmon habitats be undertaken as soon as possible (NMFS 2014). This habitat data could be used for other monitoring purposes as well.

- Recommendation: Monitor coho salmon habitat condition with a survey of existing baseline conditions. Identify where existing habitat data can be incorporated into the initial baseline survey.
- Recommendation: Implement a randomized GRTS habitat status/trend monitoring program using protocols similar to CHaMP, along with GIS analysis of land cover. Non-random, continual habitat monitoring sites should be coupled with existing/proposed LCM stations. Sproul Creek and Elder Creek could be used as continual monitoring sites, while rotating panels could sample elsewhere for spatial distribution.

As discussed in Chapter 5: Habitat Restoration, habitat restoration effectiveness monitoring would ideally be coupled with both salmonid life cycle monitoring, and a population dynamics model. A model is being developed for Freshwater Creek (Humboldt Bay) by Humboldt State University which includes spatial and stage based stock-recruit sub-models (Darren Ward, HSU, pers. comm.). Stillwater Sciences has developed a RIPPLE model focusing on population response to habitat conditions (Stillwater Sciences 2009). Both of these population models could be applicable to Eel River monitoring programs.

The North Coast Regional Water Quality Control Board has developed a Watershed Management Initiative (WMI) for Eel River sub-basins. The goal of this WMI is "*to integrate water quality monitoring, assessment, planning, standards, permit writing, nonpoint source management, ground water protection, and other programs at the State and Regional Water Boards to promote a more coordinated and efficient use of personnel and fiscal resources while ensuring maximum water quality protection benefits*." The Department of Forestry and Fire Protection, Department of Water Resources, and CDFW also conduct water quality monitoring. Water quality issues for some Eel River basins have been summarized by CDFW watershed assessments of the Salt River (CDFW 2005), the Lower Eel River watershed (CDFW 2010), the Van Duzen River watershed (CDFW 2013), and the South Fork Eel River watershed (CDFW 2014). The CDFW Coastal Watershed Planning and Assessment Program is working on an Outlet Creek watershed assessment as of 2015

- Recommendation: Integrate Regional Board and CDFW findings into monitoring plans as they become available.

Quantity of discharge has become a central issue for the Eel River, as many streamflows are being diverted, both legally and illegally. Many of these diversions occur in small, headwater streams and springs, which may be difficult to detect and isolate with limited USGS streamflow gauging stations on larger order streams. Flows of one smaller order stream are continuously monitored on the South Fork Eel River tributary of Redwood Creek. The following recommendation is discussed in Chapter 2: Water Resources:

- Recommendation: Expand CA Department of Fish and Wildlife, Regional Water Board, and State Water Board Division of Water Rights staff to investigate, regulate, and monitor water rights and water diversions.

Turbidity is monitored in relatively few locations in the Eel River watershed, primarily associated with timber harvest activities. Storm-proofing of roads is known to reduce or prevent sediment inputs, and monitoring the effects of sediment-reducing activity is necessary to document responses to these efforts. An alternative or complementary approach is to monitor how many miles of roads have been newly constructed, removed or improved. The following recommendations are found in Chapter 4: Sediment Impairment and TDML Implementation:

- Recommendation: Develop monitoring plans and programs for collecting and interpreting sediment water quality data.
- Recommendation: Develop a regional sediment monitoring program that fits with available resource levels, and begin implementing a baseline data collection program to establish a mechanism for measuring progress in sediment reduction efforts. Monitoring must link sediment reduction to improved conditions for beneficial uses. This program should include (1) a database of past and ongoing suspended sediment and turbidity monitoring data from the Eel River, (2) a TSS and turbidity monitoring program at a feasible scale that matches monitoring funding limitations, (3) a program to survey cross-sections at bridge crossings and other suitable locations to track change (recovery) of coarse sediment. This type of water quality and sediment monitoring is relatively expensive but does not need to be collected everywhere; several index sites selected to represent a range of watershed conditions will be useful now and in the future as restoration measures improve sediment conditions.

The Regional Board's SWAMP conducts long term trend monitoring for dissolved oxygen, nutrients, toxics, metals, and minerals at 17 locations in the Eel River watershed (see Chapter 3: Water Quality). Monitoring for harmful cyanobacteria (see Chapter 3) is conducted by the Eel River Recovery Project (ERRP) at several locations. SWAMP monitors nutrients and biostimulation at six locations in the South Fork Eel River watershed. SWAMP monitors physical habitat and benthic macroinvertebrates at four Eel River locations with its Perennial Streams Assessment (PSA), and at six other Eel River sites with its Reference Condition Monitoring Program.

- Recommendation: Establish water quality monitoring stations along the Eel River mainstem, to collect tidal stage, salinity and temperature, nutrients and pH, and other parameters (from Chapter 6: The Eel River Delta and Estuary.

Water temperature data is inexpensive to collect, and is gathered at many locations in the Eel River watershed by a variety of agencies. The Regional Board prepared a region-wide water temperature plan that includes a database of all available temperature data. Ongoing efforts to combine data from multiple sources are discussed in the final chapter of this document. The following recommendations are found in Chapter 3: Water Quality:

- Recommendation: Expand water temperature monitoring in priority areas, particularly sub-watersheds and stream reaches that currently support abundant coho salmon runs. For water quality monitoring expansion, the Eel River Forum needs to work with the Regional Water Board TMDL program and the State Water Board's Citizen Monitoring Program to implement standardized monitoring protocols. Monitoring data needs to link to the SWAMP program and database.
- Recommendation: Support expansion and continuation of SWAMP monitoring to track nutrients, cyanobacteria, and algae in selected Eel River locations.

Citizen Based Monitoring

Given the extent of private holdings in the Eel River basin, and limited funding available to support monitoring activities, reliance on coordinated "citizen-based monitoring" for data collection and interpretation may be necessary to obtain all needed data. Citizen groups focus on community outreach, actively monitoring Eel River resources, or both. This section focuses on issues that volunteer groups can easily address, while the next chapter discusses community outreach and collaboration in more detail.

Watershed groups and volunteer efforts already exist within the Eel River basin. Current levels of citizen involvement show that residents of the Eel River basin want to help. Providing more opportunity to help monitor natural resources may lead to more volunteer participation. The Friends of the Van Duzen have a watershed management plan and a summary of monitoring activities available at www.fovd.org. Citizen monitoring day is held at Swimmer's Delight, a popular State Park day-use area located on the South Fork Eel River. Since many citizens merely wish to know if the river is safe to enjoy on a hot day, this type of "is it swimmable" monitoring will continue. ERRP pollutant monitoring and flow studies are available online here: http://www.krisweb.com/ERRP/ERRP_Temp_Flows_ToxicBGA_final.pdf .

The following indicators are currently being monitored by citizen groups:

Temperature

The Regional Board's region-wide water temperature database can accommodate data gathered by citizen-based groups. The agency has also developed a citizen-based website http://www.waterboards.ca.gov/water_issues/programs/swamp/cwt_volunteer.shtml. Water temperature probes can be deployed with minimal training, though some instruction regarding placement, etc. may be required. Citizen group involvement in gathering agency water temperature data in the Eel River basin could be used as a template for community involvement in other monitoring areas.

Flow

Flow measurements require some technical knowledge to gather reliable results. However, ERRP has obtained State Water Board funding to monitor water temperature as a proxy for flow (Higgins 2014). Water temperature data loggers will reveal when a stream has dried up, when they begin to record ambient air temperatures. Time-lapse photo documentation of dry streambeds is another area where citizen monitoring could be especially helpful, since government workers are unable to access many areas.

Algae/Nutrients

Obtaining water samples for lab analysis is a relatively simple process. The ERRP efforts in this area should continue and expand. The following recommendation for citizen monitoring is from Chapter 3: Water Quality:

- Recommendation: Support ERRP efforts to expand citizen-based monitoring of water temperature and blue-green algae. The ERRP's largely volunteer effort has demonstrated the ability to collect valuable real-time data that can be used to supplement ongoing agency monitoring programs, particularly reaching locations inaccessible to agency personnel. ERRP should pursue efforts to collect temperature data at sites monitored previously (e.g., 1998 survey by Humboldt County Resources Conservation District), allowing a comparison of current conditions to those from the past.

Fish

The Wiyot Tribe's leadership in lamprey and sturgeon research demonstrates that a variety of entities can participate in biological monitoring. The ERRP has expressed interest in monitoring Sacramento pikeminnow populations in lieu of suppression activities which can harm salmonids (Higgins 2014). Citizen observations of Sacramento pikeminnow help determine spatial distribution trends. Citizen observations of rare fish (summer steelhead, for example), fish kills, and sturgeon in unique areas can be documented with photographic or video evidence. The collaborative effort of HRC, the Wiyot Tribe, and ERRP volunteers to survey the annual Fall Chinook salmon migration is discussed earlier in this chapter. These surveys provide an excellent opportunity for volunteers to participate in important monitoring.

Inefficient effort occurs when no guidance is given from oversight agencies, and information gathered by community group goes unused. The State Water Board created SWAMP's Clean Water Team to communicate directly with citizen monitoring organizations. The Clean Water Team has a handbook, http://www.waterboards.ca.gov/water_issues/programs/swamp/cwt_guidance.shtml and a toolkit, http://www.waterboards.ca.gov/water_issues/programs/swamp/cwt_toolbox.shtml created specifically for citizen monitoring groups wishing to gather water quality data.

- Recommendation: Identify and use methods and protocols to be used for data collection, so data collected by citizen-based groups is of sufficient quality for agency consideration. SWAMP has a Clean Water Team devoted to this function.

Proposed Actions for Eel River Forum Consideration

The first step in developing a monitoring program is to inventory existing monitoring, find gaps to be addressed, and identify funds needed to fill gaps (Crawford and Rumsey 2011). The previous section summarizes past and current monitoring activities in the Eel River basin. The current state of knowledge for Eel River salmonids is based on efforts in a few locations in smaller order streams. This may remain the case for the foreseeable future. Expansion of monitoring will require funding, and clear goals are needed to optimize efforts. The following is a summary of recommended monitoring actions from this chapter:

1. Investigate effect of mixed-stock ocean fishery on Eel River salmon populations using methods outlined by O'Farrell (2012).
2. Install a sonic receiver detection array at sites within the Eel River sturgeon migration corridor, including marine, estuarine, and riverine areas.
3. In lieu of annual Sacramento pikeminnow suppression action, PG&E should re-scope and implement a Sacramento pikeminnow abundance monitoring plan using direct observation techniques, targeting an abundance estimate or index of abundance in the Eel River reach between Scott Dam and Cape Horn Dam, and in the reach between Cape Horn Dam and Outlet Creek. Tracking annual abundance will provide important information on population fluctuations potentially related to PVP flow releases.
4. Integrate or modify existing protocols into larger plan (CMP, Eel River Action Plan, SONCC coho salmon recovery plan).
5. Establish a sonar counting station (either DIDSON or ARIS) at the mouth of the South Fork Eel River and/or on the lower mainstem Eel River, to supplement and validate current CMP adult abundance estimates based on redd surveys.
6. Investigate and demonstrate ability to differentiate species using sonar technology for times when runs overlap.
7. Identify and employ approved adult snorkel survey protocols, including error estimation. Investigate if and how adult snorkel surveys can be used to assess adult distribution under CMP. Investigate if snorkel survey observations of species run-timing may aid in differentiation of sonar images.
8. Expand snorkel surveys for juvenile coho salmon occupancy to all accessible reaches of the Eel River.
9. Develop a procedure for collecting and archiving tissue samples for future assessment in order to track changes in genetic diversity and identify stocks.
10. Implement a randomized GRTS habitat status/trend monitoring program using protocols similar to CHAMP, along with GIS analysis of land cover. Non-random, continual habitat monitoring sites should

be coupled with existing/proposed LCM stations. Sproul Creek and Elder Creek could be used as continual monitoring sites, while rotating panels could sample elsewhere for spatial distribution.

11. Monitor coho salmon habitat condition with an initial survey of baseline conditions. Identify where existing habitat data can be incorporated into the initial baseline survey.
12. Implement a randomized GRTS habitat status/trend monitoring program using protocols similar to CHaMP, along with GIS analysis of land cover. Non-random, continual habitat monitoring sites should be coupled with existing/proposed LCM stations. Sproul Creek and Elder Creek could be used as continual monitoring sites, while rotating panels could sample elsewhere for spatial distribution.
13. Integrate Regional Board and CDFW findings into monitoring plans as they become available.
14. Expand CA Department of Fish and Wildlife, Regional Water Board, and State Water Board Division of Water Rights staff to investigate, regulate, and monitor water rights and water diversions.
15. Develop monitoring plans and programs for collecting and interpreting sediment water quality data.
16. Develop a regional sediment monitoring program that fits with available resource levels, and begin implementing a baseline data collection program to establish a mechanism for measuring progress in sediment reduction efforts. Monitoring must link sediment reduction to improved conditions for beneficial uses. This program should include (1) a database of past and ongoing suspended sediment and turbidity monitoring data from the Eel River, (2) a TSS and turbidity monitoring program at a feasible scale that matches monitoring funding limitations, (3) a program to survey cross-sections at bridge crossings and other suitable locations to track change (recovery) of coarse sediment. This type of water quality and sediment monitoring is relatively expensive but does not need to be collected everywhere; several index sites selected to represent a range of watershed conditions will be useful now and in the future as restoration measures improve sediment conditions.
17. Establish water quality monitoring stations along the Eel River mainstem, to collect tidal stage, salinity and temperature, nutrients and pH, and other parameters (from Chapter 6: Estuary).
18. Expand water temperature monitoring in priority areas, particularly sub-watersheds and stream reaches that currently support abundant coho salmon runs. For water quality monitoring expansion, the Eel River Forum needs to work with the Regional Water Board TMDL program and the State Water Board's Citizen Monitoring Program to implement standardized monitoring protocols. Monitoring data needs to link to the SWAMP program and database.
19. Support expansion and continuation of SWAMP monitoring to track nutrients, cyanobacteria, and algae in selected Eel River locations.
20. Support ERRP efforts to expand citizen-based monitoring of water temperature and blue-green algae. The ERRP's largely volunteer effort has demonstrated the ability to collect valuable real-time data that can be used to supplement ongoing agency monitoring programs, particularly reaching locations inaccessible to agency personnel. ERRP should pursue efforts to collect temperature data at sites monitored previously (e.g., 1998 survey by Humboldt County Resources Conservation District), allowing a comparison of current conditions to those from the past.
21. Identify and use methods and protocols to be used for data collection, so data collected by citizen-based groups is of sufficient quality for agency consideration.

9: COMMUNITY ENGAGEMENT AND INFORMATION-SHARING

Summary of the Issue

The Eel River watershed encompasses a vast, rural area, with distinctly different human communities within its boundaries. These communities have varying capacities and needs for collecting and sharing data and conducting habitat restoration, water conservation, and other actions recommended throughout this Plan. There have been recent efforts to unite the watershed to achieve larger-scale goals, both via the Eel River Forum and as discussed below. The Eel River Forum recognizes that sharing information about watershed health, as well as coordinating and empowering citizen efforts, are critical to recovery of the aquatic species and health of the Eel River watershed.

This chapter provides a starting point to understand which organizations are working or have recently worked on Eel River issues, what processes exist and should exist to share information and communicate priorities, what challenges exist, and what actions the Forum in particular can address.

Although many larger questions related to community engagement are not answered in this chapter, the Forum recognizes their importance and encourages their ongoing discussion. These include, but are not limited to, the following questions that arose during the writing of this document:

- How best to foster behavioral change in our communities that protects watershed health?
- How can the need to protect public trust resources and values be balanced with landowner rights?
- What is the most effective way for citizens to provide information to outside decision-makers about what they are seeing/ experiencing in their watersheds?
- How can county or statewide initiatives or incentives assist in better watershed stewardship?

Status of community engagement efforts

This section provides the current status, in broad strokes, of the following types of groups that are active in the watershed. The specific groups engaged in outreach efforts are categorized and comprehensively listed in the next section of this chapter (see Table 9).

Citizen-based - There are many groups working on a sub-watershed scale or on specific watershed needs/ issues. Information about these groups is listed in the next section of this chapter. The Eel River Recovery Project is an energized group currently working within the entire Eel River Watershed. Other groups have a citizen-based component of their work related to specific projects, including the Salmonid Restoration Federation, Friends of the Van Duzen, and others. Staff from these organizations also work toward other goals to benefit the Eel River watershed. These efforts are ongoing. Due to the South Fork Eel River's high fishery value to anadromous salmonids, including federally and state-listed coho salmon, there is an ongoing emphasis to restore and address water shortages in the South Fork Eel River and its sub-watersheds. There is also a strong emphasis on environmental education and many different, unique, engaging approaches to educating the next generation about the importance of watershed health.

Governmental organizations – Both the CA Department of Fish and Wildlife (CDFW) and the National Marine Fisheries Service (NOAA Fisheries) are active in working toward recovery of the fish populations and ecosystems of the Eel River. The CDFW's Coastal Watershed Planning and Assessment program identified factors and actions related to recovery in comprehensive reports prepared for several sub-watersheds of the Eel River. NOAA Fisheries released the Southern Oregon–Northern California (SONCC)

Coho Salmon Recovery Plan in late 2014, which provides a list of actions that, if implemented, are expected to lead to recovery of the species. CDFW released their Recovery Strategy for California Coho Salmon in 2004, which contains a similar list. The two agency's priorities drive much of the grant-funded restoration work in the watershed. Other agencies, including CA State Parks, the U.S. Forest Service, and the Bureau of Land Management, have holdings within the Eel River watershed that are managed for specific purposes including natural resource conservation.

Non-profit organizations – Many non-profit organizations are active in the Eel River watershed, and engage with the community around certain projects and efforts. Some non-profits utilize government agency funding, yet rely on positive relationships with the community that result from their independent non-profit status. Many stem from grassroots efforts, and retain a level of trust from the community.

Business organizations – Business entities in the Eel River engage with the community at large and share their research findings. Pacific Gas and Electric, owner and operator of the Potter Valley Project, currently shares flow and fisheries data related to the Potter Valley Project with the community, and will seek public comment during the FERC relicensing process for this hydropower project in coming years. See the Potter Valley project chapter for more detail. Other for-profit entities in the Eel River who regularly engage with the community regarding watershed health needs and findings include timber companies (Humboldt Redwood Company, Mendocino Redwood Company, and Green Diamond Resource Company), private landowners who conduct other operations and are engaged in stewardship activities, and several groups that conduct trash clean-ups throughout the Eel River. Restoration projects employ consultants in the management of resources and affiliated outreach efforts. The restoration field also creates a source of employment and jobs in rural areas with limited opportunities.

Native American Tribes – The Wiyot Tribe, whose ancestral territory includes much of the lower Eel River, has an engaged environmental department and has actively sought funding for projects with multi-species benefits, including a study which includes an analysis of lamprey distribution and fish passage needs. The Wiyot Tribe also provides input regarding projects that would impact the tribe's sovereignty and management of fishery and watershed resources, which also have cultural and spiritual importance to its members. The Bear River Band of the Rohnerville Rancheria, also present in the lower Eel River area, also has an environmental program in place. Further upstream, the Round Valley Tribes and Cahto Tribe are also active in the management of resources. A section of land along the upper mainstem Eel River formerly managed by PG&E is being transferred to the Potter Valley Tribe to be managed for its recreational and habitat value. This transfer process will involve the public and members of the tribe, and as recreational activities are made more available, outreach will be needed.

Organizations Involved in Community Engagement

The following organizations are all currently working, or have recently worked, in the Eel River watershed and their areas of focus include community engagement. Organizations who are charter members of the Eel River Forum are indicated with an asterisk (*) after their name. Please note that the Eel River Forum, a group comprised of many of these organizations' representatives, is separately noted in the next section of this chapter.

Table 9. Organizations involved in Eel River Watershed Community Engagement as of June 2015.

Grassroots, Non-Profit and Community-based Groups	Organization Name	Website	Directly support or conduct landowner/ citizen-based restoration	Conduct monitoring	Communicate Eel conditions/ newsletter/ website with regular updates	Community gatherings or forums	Classroom or field education for K-12 or University students	Watershed advocacy	Other (explanation provided)
	Eel River Recovery Project	Eelriverrecovery.org	x	X	x	x	?	x	
	Friends of the Eel River *	FOER.org	?		x	?	?	x	
	Friends of the Van Duzen*	FOVD.org	?	?	x	?	x	x	
	Salmonid Restoration Federation *	Calsalmon.org	x	X	x	x		x	Peer training in restoration
	Eel River Salmon Restoration Project	http://ice.ucdavis.edu/ education/esp179/?q= node/408	x						Unknown current activities
	Eel River Watershed Improvement Group*	ERWIG.org	x		?	?	x	x	
	The Wildlands Conservancy	http://www.wildlandsc onservancy.org/preserv e_eelriver.html	x	x	x	x	x	x	Manages Eel River Estuary Preserve
	Yager-Van Duzen Environmental Stewards		x	X	?	x	?	x	
	Emerald Growers Association	Emeraldgrowers.org				x			Education and BMPs
	Eel River/ Russian River Commission	http://www.eelrussianr iver.org/				x			Political decision making, forums and public meetings
	Native Fish Society	http://nativefishsociety .org/							
	PacOut Green Team	Pacificoutfitters.com/ pacout-greenteam/						x	River cleanups
	Mendocino County Resource Conservation District	MCRCD.org	x	x					?
	Humboldt County Resource Conservation District	HCRCD.org	x	x					
	Salt River Watershed Council	http://saltriverwatersh ed.org/		x					
	California Trout*	Caltrout.org	x		x	x			

	Trout Unlimited	TU.org							
	Mendocino Land Trust	http://www.mendocinolandtrust.org/							
	Willits Environmental Center								
	North Coast Regional Land Trust	NCRLT.org							
	Redwood Forest Foundation Inc	http://www.rffi.org/							
Government Agencies, Tribes, Educational Institutions and Land Management Organizations	**Organization Name**	**Website**	**Directly support or conduct landowner/ citizen-based restoration**	**Conduct monitoring**	**Communicate Eel conditions/ newsletter/ website with regular updates**	**Community gatherings or forums**	**Classroom or field education for K-12 or University students**	**Watershed advocacy**	**Other (explanation provided)**
	National Marine Fisheries Service*	NMFS.NOAA.gov	x		x	x			
	CA Department of Fish and Wildlife *	Wildlife.CA.gov	x	X	?	x	x		CWPAP website coastalwatersheds.ca.gov
	CA State Parks*	Parks.CA.gov		X			x		
	Wiyot Tribe*	Wiyot.us	x	X	?	x	?	x	
	Round Valley Tribes	RVIT.org							?
	Cahto Tribe	Cahto.org							?
	Bear River Rancheria	BRB-NSN.gov							?
	U.C. Davis	UCDavis.edu					x		
	U.C. Berkeley	Berkeley.edu		x		x	x		
	North Coast Regional Water Quality Control Board *	Waterboards.ca.gov/ northcoast/		x		x			
	Humboldt State University	Humboldt.edu		x			x		
	California Conservation Corps/ AmeriCorps Watershed Stewards Project	CCC.CA.gov/work/programs/AmeriCorpsPrograms/wsp/Pages/wsp1.aspx	x				x		
	Natural Resource Conservation Service	NRCS.USDA.gov	x			x			Active in South Fork; estuary
	CA Coastal Conservancy*	Scc.ca.gov							
	US Bureau of Land Management *	http://www.blm.gov/ca/st/en/fo/arcata/wilderness/south_fork_eel_river.html							South Fork Eel Wilderness emphasis

Business Organizations	Organization Name	Website	Directly support or conduct landowner/ citizen-based restoration	Conduct monitoring	Communicate Eel conditions/ newsletter/ website with regular updates	Community gatherings or forums	Classroom or field education for K-12 or University students	Watershed advocacy	Other (explanation provided)
	Pacific Gas and Electric Company *			x					
	Humboldt Redwood Company			x					
	Mendocino Redwood Company			x					
	Green Diamond Resource Company	GreenDiamond.com		x					
	GHD Inc	GHD.com/usa/							Technical assistance and support
	Michael Love and Associates	H2odesigns.com							Technical assistance, training and support
	Stillwater Sciences	StillwaterSci.com							Technical assistance and support
	Pacific Watershed Associates	PacificWatershed.com							Technical assistance and support to landowners, publication of educational materials/ BMPs
	Ross Taylor and Associates	RossTaylorandAssociates.com							Technical assistance and support

Information sharing and watershed health communication

Access to a common database of Eel River fish, habitat and other watershed health data, including a document library, has been recognized as a need in the Eel River. Many agencies and non-profit organizations have produced plans and documents on a subwatershed or watershed-wide scale that are not easily located. A common framework is important for assessing progress over time, sharing valuable information, and engaging residents in actions on a smaller scale that have significant collective impacts. The Klamath Basin Monitoring Project provides one possible template, amongst many possible options, for data coordination and communication within a large watershed with multiple agencies involved. There are a number of other models and options for information sharing and communication. The Eel River Forum could select the most appropriate model, and move forward with database and communication management. Existing information libraries with web links to a large quantity of information or unique resources are listed below:

- Eel River Recovery Project reports and document library: http://www.eelriverrecovery.org/reports.html
- Salmonid Restoration Federation – Redwood Creek (South Fork Eel River) Resources and Documents: http://www.calsalmon.org/srf-trainings/redwood-creek-water-conservation-project (Note: SRF also has many other Eel River related documents online, but not all in one place)
- Eel River Forum – CalTrout hosts and maintains a record of Eel River Forum meeting minutes, presentations from subject matter experts, a document library and other Forum-related information at: http://caltrout.org/regions/north-coast-region/eel-river/eel-river-forum/; other CalTrout reports and Eel River project information/ updates are available at: http://caltrout.org/regions/north-coast-region/eel-river/
- Potter Valley Irrigation District: http://pottervalleywater.org
- Friends of the Van Duzen River resource information: http://fovd.org/
- Mendocino Resource Conservation District water conservation resources: http://mcrcd.org/drought-water-conservation-resources/
- Marijuana cultivation BMP guide: https://go.treesfoundation.org/inspiring/farmersguide/

Eel River Forum's role (past/ current and anticipated)

The Eel River Forum is comprised of a broad range of Eel River stakeholders. The mission of the Eel River Forum is to coordinate and integrate conservation and recovery efforts in the Eel River watershed to conserve its ecological resilience, restore its native fish populations, and protect other watershed beneficial uses. These efforts are also intended to enhance the economic vitality and sustainability of human communities in the Eel River basin. The Eel River Forum initiated this Action Plan to help address and clarify the mechanisms by which agencies and "people on the ground" communicate information. The Eel River Forum embarked on this Action Plan to help clarify and improve the mechanisms by which agencies and those most familiar with the Eel River's natural resources communicate information. The Eel River Forum also currently acts as an interim information clearinghouse, until another database/ basinwide monitoring program and communication platform is established. Eel River Forum information is located at http://caltrout.org/regions/north-coast-region/eel-river/eel-river-forum/

Challenges

The Eel River watershed presents unique challenges with respect to watershed-wide communication and community engagement. Residents live in a rural, sparsely populated, vast geographic area, amidst challenging terrain. Limited infrastructure, including roads, internet access, and cell phone reception, are barriers to easy communication. Cultural factors also present challenges, including concerns about privacy, mistrust of government, and people living in isolation by choice. Marijuana cultivation has drastically altered the communities throughout the Eel River, particularly rural communities. While these impacts are included in other chapters, the social, economic and cultural impacts have also been significant factors in coordinating watershed outreach and planning.

There are significant challenges of integrating sub-watershed efforts into a basin-wide framework due to limited resources for coordination, the fact that the Eel River watershed's boundaries extend into five counties, and the ongoing struggle of managing competing resources in the watershed. Additionally, there is a communication gap between agencies, citizen-based groups, tribes, schools/ universities, for-profit groups, et cetera, and some Eel River Forum members have suggested this may be due to the lack of an agreed-upon basinwide framework for communication and data sharing.

Proposed actions for Eel River Forum consideration*:*

1. Compile and make available an Eel River watershed document library,
2. Identify best configuration of database and identify models/ platforms,
3. Identify or establish a group to be an active "information clearinghouse"
4. Share funding opportunities at ERF meetings and provide capacity-building resources,
5. Coordinate future community events/ forums to share watershed information and involve people in ERF,
6. Communicate between agencies and citizen-based groups to determine how to collect the most usable data, establish protocols, and build trust,
7. Share meeting information/ summary in brochures after each meeting,
8. Publicize meetings of the ERF on local community calendars,
9. 1:1 outreach to delegates from watershed stakeholders and policymakers to keep them involved and to get new people involved,
10. Broaden support for and input to future prioritization process for Eel River actions,
11. Learn and share what is and is not working from the community with regard to watershed health on an ongoing basis,
12. Develop a mechanism for residents to get information to agencies,
13. Provide support to the CDFW's Coastal Watershed Planning and Assessment Program -advocate for continued funding for watershed coordinators and increased staffing,
14. Support efforts to work on a sub-watershed scale to identify additional actions and implement recovery actions with willing community partners,
15. Develop an economic index of how restoration activities impact economic growth.

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APPENDIX A: EEL RIVER RECOVERY PROJECT PLANNED MONITORING

Background

ERRP was formed in late 2011 in response to concern about reduced Eel River flows, emerging water quality problems that include toxic algae, and the future of salmon runs. The ERRP mission is "to empower communities to work collaboratively to monitor the ecological condition of the Eel River, to share information about the health of the watershed, and work together to formulate and implement a restoration strategy." The organization is not advocacy oriented and rather tries to work with the community on solutions to identified problems. We have adopted the citizen-science or volunteer monitoring model (US EPA 1997), with scientists going into the field to assist with placement of equipment and to maintain data quality control. Involving citizens builds trust and data over time can be used to gage environmental trends, including response to restoration efforts. Since preliminary information suggests that flow is diminishing and nutrients increasing (Higgins 2012), ERRP is also beginning an educational outreach program to solve these problems (ERRP 2013).

Figure 1. Water Day 2013. 3/30/13.

ERRP constantly scopes the community regarding changing needs and in order to assess priorities and get feedback on whether existing programs are working. One of the ways we stay in touch is through Water Day, a large outreach event held annually in Spring at the Mateel Community Center (Figure 1 at left). Our vision is to build monitoring capacity into the culture of the community so that people can better understand Eel River ecological function and maintain and enhance it into the future.

In 2012 and 2013, ERRP conducted basin-wide water temperature and flow, algae, and fall Chinook salmon monitoring. Hundreds of volunteer hours with strategic professional support led to collection of sound data and valuable insight that has been shared with the community via reports, the press, public meetings, and the ERRP website (www.eelriverrecovery.org). Raw data and related products such as GIS are also available to agencies, Tribes, and other non-profit groups. ERRP has cooperative working relationships with the North Coast Regional Water Quality Control Board (NCRWQCB), California State Parks, Mendocino County Water Agency (MCWA), Six Rivers National Forest, University of California Berkeley (UCB), Humboldt County Department of Health and Human Services (HCDHHS), Redwood Forest Foundation, Inc. (RFFI) and the Humboldt County Parks Department (HCPD).

ERRP annually holds a Retreat to report progress on the past year's activities and to forge an Action Plan (ERRP 2011, 2013, 2014) for the coming year. What is encompassed below overlaps with the content of the *ERRP Action Plan* (2014), but provides greater scientific detail. The restoration suggestions may be better considered separately by the Forum because tasks are not for ERRP performance. ERRP wishes to serve as a catalyst for restoration project implementation by local entities such as the Eel River Watershed Improvement Group (ERWIG), Eel River Salmon Restoration Project (ERSRP), Cal Trout, Humboldt County Resources Conservation District (HCRCD) and other private restoration practitioners and would help support funding requests. ERRP has had preliminary discussions with some but not all private land owners where projects are proposed, but has reason to believe many are receptive.

Monitoring Projects

Many residents of the Eel River have a strong interest in Natural History and science and enjoy learning and participating in the process of scientific discovery. ERRP uses science to frame hypotheses and to test for trends in the health of the river and its tributaries. Attendees at the original community forums in 2011 (ERRP 2011) said they wanted to participate in data collection on toxic algae to better understand it and possibly work to eliminate it. Others thought they were seeing the diminishment of flow of the Eel River and its tributaries, but there were no data to confirm their observations. The community also had concerns about the future survival of the salmon and the hostile take-over of the river by the non-native Sacramento pikeminnow.

ERRP has been able to provide technical assistance to citizens, help frame hypotheses, and to acquire resources and equipment to conduct studies to test them with scientific methods. All ERRP data meet quality assurance and quality control objectives and are shared with the public, agencies and Tribes. ERRP would like to work with cooperators in the Eel River basin to assemble a publicly available database that can be used for trend monitoring and adaptive management.

Toxic Algae

The Eel River has begun to develop toxic blue-green algae or cyanobacteria in its margins over the last two decades, when it never had such problems historically. Toxic algae blooms do not happen in all years (Higgins 2013) and the magnitude of the problem seems dependent on air and water temperature patterns and flow (Figures 2-3). The Eel River is not unique, as water bodies that are out of ecological balance around the planet are also harboring major cyanobacteria blooms, including toxic species (Paerl 2012). Since blue-green algae species have been in existence for a billion years, it is likely that an ecological shift in Eel River conditions has made the lower river margins more suitable for them. ERRP/UCB cooperative studies will test the following hypothesis:

> *Eel River toxic blue-green algae blooms are in response to channel changes, decreased flow, and increased nutrient loads.*

The Humboldt County Department of Public Health (HCDPH) has documented 11 dog deaths since 2001 on the Van Duzen and South Fork Eel River , but none since 2009 (Hill 2010). While Microcystis aeruginosa, which attacks the liver, is the toxic cyanobacteria that dominate the Klamath River and its hydropower reservoirs, Eel River toxic algae species have been identified as Anabaena and Plaktothrix that produce neurotoxins (Puschner et al. 2007).

Keith Bouma-Gregson is a doctoral student at the University of California at Berkeley in the Mary Power Laboratory who is heading up the ERRP algae studies. In 2013, volunteers assisted Keith with data collection (Figure 4) at 8 locations spread throughout the Eel River watershed where he measured

1. Algae species along transects,
2. Nutrients,
3. Temperature, and
4. Ambient water levels of cyanotoxins.

Figure 2. Humboldt County Public Health staff Harriet Hill samples toxic algae on the SF Eel River at Phillipsville in August 2009. HCDHHS.

Figure 3. September 2012 photo above is of the same location on the SF Eel as photo at left and shows no sign of toxic algae. Higgins 2013.

Cyanotoxins were measured using resin devices analyzed in cooperation with the UC Santa Cruz Laboratory and five of eight locations had cyanotoxins (Bouma-Gregson personal communication). While neurotoxins characteristic of Anabaena were found at four locations, Microcystin was also measured on the upper South Fork. Preliminary results are expected in February 2014 and Keith expects to expand locations where monitoring is conducted to include more highly used swimming spots. ERRP will also be organizing citizens to take pictures at highly used recreational locations as part of the “Is It Swimmable?” project. ERRP members were trained to identify toxic cyanobacteria species at the 2013 Angelo Reserve Algae Foray put on by UC Berkeley (Figure 5) and can screen local samples for potentially toxic species before they are sent to the lab.

Figure 4. Keith Bouma-Gregson instructs ERRP volunteers David Sopjes and Sal Steinberg on how to measure algae species along a transect on the Van Duzen River. Photo courtesy ERRP. 6/23/13.

Figure 5. Nationally known algae specialist Dr. Rex Lowe (left) assists ERRP volunteers David and Barbara Sopjes with species identification at UC Angelo Preserve Algae Foray. Photo courtesy ERRP. 6/23/13.

Water Temperature and Flow

Helping the community understand flow trends is one of the most valuable services ERRP provides, but the forensic method being used is to analyze water temperature as a surrogate. The hypothesis being tested is one put forth by dozens of citizens during ERRP forums:

Stream flow has diminished as a result of increased agricultural diversions and domestic water use since the passage of Prop 215 in 1996.

Water temperature reflects flow volume and transit time (Pool and Berman 2000); therefore, historic U.S. Geologic Survey flow data, precipitation data and air temperature data will be used to explore whether flow depletion is causing increasing water temperature trends. Protocols for probe placement and for maintaining quality assurance follow the guidelines of Lewis, et al. (2000), similar to all previous Eel River temperature studies. Where possible, probes are placed at or near sites previously occupied (Friedrichsen 1998). Exact locations of temperature monitoring locations are established using the global positioning system (GPS). ERRP has been measuring temperature at 50-70 locations in 2012 and 2013 but would like to expand to include all locations previously monitored. Baseline data were collected or acquired for use by Friedrichsen (1998) and include 216 locations throughout the Eel River basin in 1996 and 227 locations in 1997. The Humboldt County RCD (1999, 2001, 2002, 2003) continued to collect similar data until 2003. Earlier temperature baseline data are also available from Kubicek (1977) and reflect basinwide temperature regimes following the 1964 flood.

ERRP assists dozens of volunteers throughout the watershed (Figure 6-7), and in some cases, the location of probe placement was selected to answer their questions. Did an earthflow on Dobbyn Creek degrade salmon habitat? How do beaver dams in Outlet Creek affect flows and water temperatures? Do pools that have become isolated because of dropping flows maintain groundwater connections and their ability to sustain juvenile steelhead in Chemise Creek?

Figure 6. Proud Savage (l) and Walker Wise point to Chemise Creek automated temperature probe. Photo courtesy ERRP. 7/4/13.

Figure 7. Stephanie Stephano-Davis (l) holds note book while her son John-Henry holds automated temperature probe. Photo courtesy ERRP. 7/23/13.

ERRP has an Optic Pro Reader that allows each automated temperature probe to be checked at least once during the field season as per Lewis et al. (2000), which allows re-locating probes that are in dry side channels or replacement of a gauge that has been stolen or vandalized. ERRP volunteer coordinators are responsible for probe calibration, teaching and training volunteers, over-seeing mid-season data checks, and collection of probes. An exception is probes loaned to ERRP by the NCRWQCB, which are calibrated by their staff. MCWA has also supplied ERRP with automated temperature probes, but ERRP maintains and calibrates them.

Grant funds support ERRP contract services that include downloading data using Onset Instrument Hoboware, trimming outliers such as air temperatures while the probe was in transit before placement, and entering data into a standard database formats (i.e. Excel, Access) for analysis. These final QA/QCed data are shared with all cooperators, including publication to the Internet. An annual report of findings is prepared and circulated for review and then published and shared, including through the ERRP website and via public presentations. Spatial data of probe and photopoint locations will be translated into Google Map projects so the public can see results on the Internet, while agencies can acquire data in ArcGIS for quantitative analysis.

Photopoints that capture upstream and downstream conditions are also established at each probe site. These can clearly demonstrate flux in flow, which is invaluable information for this project. Do creeks have variable flow, briefly dry up in an unpredictable pattern, or go completely dry?
Knowledge of water use patterns is essential for helping target conservation efforts. The Salmonid Restoration Association is currently measuring flow at a number of locations in Redwood Creek and the feasibility of establishing a wider flow data monitoring system will be explored cooperatively. Photopoints will also prove extremely useful in helping assess long term trends like riparian recovery. Conversely, if a major storm event causes catastrophic change, the photo documentation can help judge flood damage impacts.

Understanding water temperature regimes also provides key information on suitability for salmonids (McCullough 1999) and to establish where there are thermal refugia (Bradbury et al. 1995). For example, the maximum floating weekly average temperature can be used to determine whether it is likely coho salmon are present or absent (Welsh et al. 2001). Water temperature data are also collected in conjunction with the toxic algae monitoring project throughout the basin and by the ERRP fall Chinook monitoring project that surveils the lower Eel River. Water temperature data are also expected to be contributed by cooperators, such as HRC and the HCRCD, as well as other State and federal agencies.

Fall Chinook Basin-wide Monitoring

By acquiring strategic grant funds and tapping the tremendous good will of the community, ERRP has been able to conduct successful dive counts of fall Chinook salmon in the lower Eel River and also to document the migrations and spawning concentrations. In aggregate these yield trend data for early fall-run in the lower Eel River and provide a basis of understanding of Chinook salmon distribution and relative abundance basin-wide (Higgins 2012, 2013). In 2013- 2014, dives have extended through January, because conditions remain optimal for direct observation. ERRP organizes the dives and interior basin reconnaissance because:

- The Community wants more information than has previously been collected and shared,
- Ability of agencies to expand data collection on fall Chinook is low due to shrinking budgets,
- Need to know about abundance to make sure fall Chinook salmon are not declining and as an index of the success of basin-wide restoration and ecosystem function,
- Monitoring lower Eel River holding conditions could provide impetus for restoration action, and
- The Community is willing to support both via participation and monetarily.

The methods employed in dives are standard direct observation techniques similar to those utilized by the U.S. Forest Service and Salmon River Restoration Council for Klamath and Trinity summer surveys, and by the California Department of Fish and Wildlife (CDFW) for spring Chinook in Butte Creek (Garman 2012). For a complete methods description, please see previous reports (Higgins 2010, 2013) and ERRP (2013) protocols. In 2013, ERRP conducted lower Eel River habitat mapping prior to dives to better understand which pools might be used by holding Chinook salmon and where within the pools salmon were likely to be concentrated. This allowed dive teams to better anticipate fish concentrations and do a better job of counting. Humboldt Redwood Company (HRC) and the Wiyot Tribe once again co-sponsored and participated in lower Eel dives (Figure 8). ERRP volunteers have gained substantial dive experience and participation by agency and private professional fisheries biologists remains high. Repeated counts to calibrate previous survey results showed a narrow variance in 2013.

Figure 8. ERRP volunteer Larry Bruckenstein, Julie Donnell (HRC), Tim Burton and Eddie Koch of the Wiyot Environmental Department and Nick Simpson (HRC) about to dive the pool at the convergence of the Eel and Van Duzen rivers as part of 2013 calibration survey. Photo courtesy ERRP. 10/21/13

ERRP uses existing data collected by CDFW, such as the Van Arsdale Fish Station counts and mainstem and tributary index reaches, and PG&E (2006, 2007, 2008) Upper Eel/Tomki Creek surveys, as they are made available. Historical reference data of greatest value are the USFWS (1960) Eel River-wide Chinook salmon survey for the years 1955-1958 and Benbow Dam counts on the South Fork Eel River (Gibbs 1964), which help understand spatial and temporal patterns of migration and spawning. ERRP's extensive volunteer network relays observations of mass migrations and location of spawning areas and capture photos and video. As with citizen temperature monitoring, ERRP contractors do field visits and assist with documentation and reporting. The unusually low flow conditions from November 2013 through January 2014 allowed for repeated checks of spawning areas to check for Chinook with varying run timing.

Canoes and kayaks were also used to survey over 30 miles of lower main Eel River and lower South Fork (see www.eelriverrecovery.org/fish.htm). Date were collected on the number of live fish, carcasses, location and size of redd areas, and water temperature. Redd and carcass surveys often included capturing video of spawning fish that are also posted to the Internet.

In addition to winning grant resources for 2013-2014 fall Chinook monitoring from Patagonia and the Salmon Restoration Association funding was provided by individuals and businesses through the Penny for a Salmon project. The combination of high enthusiasm of the community for participating in dives and the willingness of people to contribute support for this project mean that it is likely to be sustainable into the future. ERRP is happy to provide this mechanism for tracking salmon populations that connects the community with these magnificent fish runs that have such traditional importance and represent an index of our quality of life.

Warm Water Fish Monitoring Including Sacramento Pikeminnow

After the 1964 flood, the Eel River mainstem environments were dominated by native Sacramento suckers because the changes in channel morphology and water temperature favored them over salmon and steelhead species. However, introduction of the Sacramento pikeminnow (aka squawfish) circa 1980 into Pillsbury Reservoir caused a wholesale change in the fish community within 20 years (Brown and Moyle 1991, 1991a, 1997, Clancy 1993, Harvey and Nakamoto 1999, Harvey et al. 2002, Nakamoto and Harvey 2003). Many watershed residents feel that the pikeminnow population should be controlled, but ERRP would like to stimulate collection of more data on pikeminnow before any management actions are considered.

There are numerous accounts by watershed residents (Geoff Davis, Jeff Hedin, Bill Reynolds personal communication) of heavy and coordinated predation of pikeminnow by otter families. ERRP would like to get research funds for the Humboldt State Otter Project to be able to assign a graduate student to test the hypothesis:

The Eel River watershed otter population has increased in size to take advantage of the huge biomass of the introduced Sacramento pikeminnow, which is changing their distribution and abundance.

Brown and Moyle (1997) and Clancy (1993) indicated that the pikeminnow population had exploded. A total of 267,000 pikeminnow were counted in the Eel River during a one day volunteer dive that had 80 divers and covered over 140 miles of mainstem Eel River habitat in September 1993 (Clancy 1993). However, recent ERRP biologist and citizen scientist observations are that pikeminnow are more patchy in distribution and are often near large wood jams or in pools deeper than 20 feet (Figure 9), possibly to enable evasion predation (Higgins 2013b).

The chief concern with pikeminnow is that fish over 10 inches in length (250 mm) shift their diet and are more likely to consume salmonids (Nakamoto and Harvey 2003). Larger and older adults not only have

Figure 9. Adult pikeminnow (>250 mm) holding in a large wood tangle in the High Rock Pool. Photo courtesy of ERRP. 8/15/12.

the potential to consume more salmonid juveniles, they also have high reproductive capacity. Harvey and Nakamoto (1999) established that large adult pikeminnow take up residence in large pools but may range 52 km to spawn. Larval drift indicates that pikeminnow highly utilize warm tributaries and that many fish species formerly inhabiting the main Eel River have moved into tributaries due to pikeminnow predation (Harvey et al. 2002).

ERRP would like to have the assistance of a UC Davis graduate student to study the warm water fish populations of the Eel River and compare them to former surveys (Brown and Moyle 1991). In addition, ERRP would coordinate volunteer dive teams to collect data on the distribution and abundance of pikeminnow in key reaches throughout the Eel River watershed. One emphasis of the UCD study would be the distribution and abundance of the native Sacramento sucker to test the following hypothesis:

Native sucker populations are rebounding, at least in some sub-basins, in response to declining pikeminnow numbers, as the Eel River reaches a new ecological balance.

NMFS (2002) called for PG&E to expend resources to control pikeminnow within the Potter Valley Project affected reach of the main Eel River, but that proved infeasible (PG&E 2006, 2007, 2008). ERRP is hoping that unused funds could be applied basin-wide.

Distribution of Non-Native Snail Radix auricularia- On August 31, 2013, Dr. Mary Power was helping sample the lower Eel River above Fernbridge with graduate student Charlene Ng when she identified a snail in the net designed to catch drifting algae (Figure 10).

Figure 10. Dr. Mary Power and Radix. 8/31/13

UC graduate Nicholas Burnett (2013) identified the snail as Radix auricularia, which is native to central Europe. This snail is known to be present in several other states but this is the first confirmation in northern California. ERRP dive teams noticed that Radix is extremely abundant in shallower portions of lower Eel River pools and UCB has identified them on the upper South Fork Eel, although at low densities. Because it is a pulmonate snail, having the equivalent of lungs, it can also float downstream as a mechanism for dispersal.

The discovery by UCB indicates that a non-native snail species is widespread and its ecological impacts to the benthic community are unknown. Will it out compete native snails and change the community structure? What other ecological effects might it have? In addition to potential research partnerships, ERRP will also organize volunteer effort, including involving schools, to see what the distribution and abundance of Radix is basinwide.

Since it can float downstream and it is present in the headwaters of the South Fork, it is possible that it was introduced there and floated downstream. The snail would have a harder time extending its population upstream, especially given the high seasonal flows and bed scour often associated with winter storms in the Eel River watershed. Therefore, if Radix is absent in the Van Duzen, not far upstream of the lower Eel pools that are a major population source, then it was recently introduced. Similarly, how far upstream of Dyerville on the main Eel River is Radix distributed? If the origin is the South Fork and the time of introduction is recent, then there should be no Radix in the Middle Fork or North Fork. A likely source for Radix is from a water storage pond where it was accidentally imported on vegetation to improve aesthetics.

ERRP is prepared to test the following hypothesis:

Radix auricularia was introduced into the Eel River by escape from a farm pond somewhere in the upper South Fork Eel River basin.

Ponds are also major sources of bull frogs, which can decimate native frog populations, and warm water fish species such as bass, sunfish and catfish that can dominate Eel River tributaries during summer low flow conditions (Higgins 2013b). Toxic algae findings of Keith Bouma- Gregson include Microcystin in the upper South Fork. Since the upper South Fork Eel is shaded and cold, the presence of Microcystis aeruginosa is not expected because it often thrives in warm still waters. Positive readings for Microcystin could be linked to algae blooms in farm ponds, a hypothesis that can be explored as part of toxic algae studies.

Amphibians

While more aquatic studies focus on fish, amphibians can be excellent indicators of stream health and ecological succession (Welsh and Ollivier 1999). ERRP has been approached by Dr. Bruce Bury, who is a Humboldt County native recently retired as a U.S. Geologic Survey Zoologist at the Forest and Rangeland Ecosystem Science Center in Corvallis, Oregon. Dr. Bury has some interest in helping ERRP organize surveys and is particularly concerned with about impact of introduced species, such as bullfrogs, which have invaded the Eel River basin. The hypothesis to be tested would be:

Bullfrogs are decreasing the diversity and abundance of native amphibian species, such as yellow-legged frogs, red-legged frogs, and Pacific tree frogs.

We are also in touch with Dr. Hartwell Welsh of the U.S. Forest Service PSW Research Station in Arcata, California (Redwood Sciences Lab). Dr. Welsh has data from the Eel River watershed, has helped develop keys and survey protocols for the region's amphibians (Welsh et al. 1991, Welsh and Hodgson 1997), and is intimately familiar with using amphibians as an indicator of habitat change (Welsh and Ollivier 1998). He may be available to help provide protocols and consultation as well as assist with training and to help with an ERRP basin-wide citizen- monitoring project for amphibians. Graduate student assistance for this project may also desirable.

Physical Habitat Trend Monitoring

ERRP has been working the Eel River Forum's Monitoring Committee and requested that a select group of physical habitat parameters be adopted for trend monitoring because of their known suitability for salmonids (Kier Assoc & NMFS 2008, NCRWQCB 2006). Tracking habitat suitability trends for salmonids also assists with trend monitoring of sediment and temperature TMDL (US EPA 2002, 2003b, 2004, 2005, 2007) implementation. TMDLs recognize salmonids as a target indicator of COLD water beneficial uses under the Clean Water Act. They also acknowledge reference targets for physical habitat parameters recognized as necessary to support these fish species (i.e. pool frequency and depth, amount of fine sediment in pools). ERRP (In Press) 2013 water temperature and flow monitoring found that the carrying capacity for salmonids was constrained as much by an excess of sediment as by a lack of flow (Figure 11). If sediment from road related erosion or a landslide enters a stream channel, it reduces pool volume and depth and has the potential to warm the stream by reducing surface and groundwater connections (Pool and Berman 2000, U.S. EPA 2003a). Tracking sediment supply and routing can be done using methods employed by Knopp (1993) and others (Hilton and Lisle 1993, Overton et al. 1993, Bauer and Ralph 1999). Sediment data would be used for trend monitoring.

Volume of Sediment in Pools (V)*: Pool volume is a good surrogate for juvenile coho rearing space and stream carrying capacity because of the species' recognized preference for pools (Reeves et al., 1988). Hilton and Lisle (1993) devised a method to quickly assess the ratio of the volume of sediment and water in a pool to the volume of sediment alone, to determine the residual volume of pools, and termed the measure V-star or V*. Knopp (1993) found a high correlation in northwestern California between the intensity of land use and residual pool volume as reflected by V*, with highly disturbed watersheds having values greater than 0.21. Regional TMDLs (U.S. EPA 1998, 2002, 2003b, 2004, 2005, 2007) and the NCRWQCB (2006) both use a V* score of 0.21 as a target for fully functional conditions.

Figure 11. Terrace of sediment came from tributary, which is out of view to the right, and compromised the depth and steelhead juvenile carrying capacity of the pool at the convergence with a larger stream. This is a chronic problem in southern Humboldt County and is often related to poorly constructed road networks.
Photo courtesy of ERRP. 7/8/13.

Median Particle Size (D-50): Knopp (1993) studied 60 northwestern California streams and determined a relationship between streambed median particle size, "D50" and watershed disturbance. Reduced median particle size is often associated with increased sediment loads and increased bedload mobility (Montgomery and Buffington, 1993), which can cause egg and alevin mortality (Nawa et al., 1990). Increased peak flows resulting from watershed disturbance, particularly in the transient snow zone (Berris and Harr, 1987), cause additional shear stress on the streambed and can result in an increase in D50 (Montgomery and Buffington, 1993). Revisiting locations where Knopp (1993) collected data would be extremely useful for understanding trends and also provides insight into salmonid spawning suitability.

Pool Depth: CDFG (2004) habitat typing surveys always capture data on pool depth, which is the best replicable metric for trend monitoring that comes from such surveys. Greater pool depth provides more cover and rearing space for coho and other juvenile salmonids and for shelter for migrating and spawning adults. Pool depths of three feet, or one meter, are commonly used as a reference for fully functional salmonid habitat (Overton et al., 1993; USFS, 1998; Bauer and Ralph, 1999), although much deeper pools are expected in higher order streams. Maximum pool depth in tributaries can be easily measured during stream surveys and mainstem depths on the South Fork could be measured from kayaks or canoes with a plumb line or electronically.

While main Eel River habitats above Dyerville and in the Middle Fork are in recovery from past flood impacts (Higgins 2010, 2012, 2013), the South Fork Eel appears to have major problems with sediment over-supply. Mainstem pool depth can be used for trend monitoring and to test the hypothesis:

Sediment over-supply is compromising the pool depth of the South Fork Eel River.

Turbidity is also a good tool for understanding watershed disturbance and sediment yield (Klein 2003) and impacts to salmonids (Klein et al. 2008), but such studies require expensive equipment and substantial resources for technical assistance. This requires grant resources on a higher level than more "low tech" citizen monitoring efforts and should probably be carried out with agency or university research partners.

ERRP Education Projects

Basinwide Water Conservation and Pollution Prevention: ERRP is expecting to receive a Water Conservation/Pollution Prevention Community Outreach grant from the SWRCB Clean Up and Abatement fund, which was unanimously approved on January 21 by the State Board. Funds are being dispersed to the North Coast Regional Water Quality Control Board that will manage the project. The Mendocino County RCD will join ERRP in providing public education on pollution prevention and water conservation. In addition to public meetings in population centers, the project will also fund experts in water conservation and ecologically sustainable agricultural practices (i.e. organic, permaculture) to provide technical assistance to groups and residents watershed wide. UCB scientist Keith Bouma-Gregson will also work with small South Fork Eel and lower Eel River water districts on cyanobacteria monitoring as part of this project.

ERRP and the MCRCD will work intensively in Mendocino County watersheds recognized as flow impaired, such as Tomki, Outlet and Ten Mile creeks that were formerly perennial but not lack surface flow in late summer even in wet or normal flow years (Figure 12 & 13). Ten Mile Creek will be the focus of the pilot project and outreach will be conducted in the Round Valley/Covelo area to explore need for similar assistance.

Figures 12. Outlet 6/17/12.

Outlet Creek is a major upper Eel River tributary and the photo at left shows flows on June 17 and there is high recreational use in summer when flows and water quality are suitable. The photo at right shows a dry stream bed at the same location on September 24, 2012, when this creek was perennial as recently as the mid-1990s (Friedrichsen 1998).

Figure 13. Outlet Creek. 9/24/12.

Public School Environmental Education: ERRP assisted the Friends of the Van Duzen in winning a competitive More Kids in the Woods (MKIW) federal grant for $50,000 awarded by U.S.D.A. Forest Service (USFS). The Six Rivers National Forest (SRNF) sponsored the proposal and HRC took students on numerous field monitoring trips (Figure 14) that helped provide a substantial part of the match for the grant. The project is getting 511 students out of the classroom and into the field, including all Van Duzen schools, Fortuna Union High School, and Casterlin Elementary near Blocksburg. Students are becoming aware of the bigger issues facing the watershed (high temperature, low stream flow, algae buildup, sediment) and how these factors affect salmon survival.

MKIW is also teaching about the need for students and their families to conserve water and prevent water pollution. ERRP and FOVD will be working with SRNF to apply for 2014 MKIW funding that will expand student monitoring and involve them in forest health projects. Ecology and the Arts is another important aspect to our Kids in the Woods Project, which involves students in video production, poetry, drawing, and musical compositions that tie back to the river, the salmon and the watershed. Poetry by students has been captured in a book, *The Van Duzen Voice*. For more information see www.eelriverrecovery.org/schools.html

Figure 14. Humboldt Redwood Company technician Julie Donnell, Nick Simpson HRC Hydrologist, Katherine Sanguinetti of Fortuna High School, Jamie Goble Academy of the Redwoods, and MKIW Coordinator Sal Steinberg before a coho salmon juvenile dive survey on Van Duzen tributary Root Creek. Photo courtesy of ERRP. 8/5/13.

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